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18TH NATIONAL POTATO UTILIZATION CONFERENCE

HELD AT CORVALLIS, OREGON
JULY 30 TO AUGUST 2, 1968

Agricultural Research Service
UNITED STATES
DEPARTMENT OF AGRICULTURE

THE EIGHTEENTH NATIONAL POTATO UTILIZATION CONFERENCE was held in conjunction with the Fifty-Second Annual Meeting of the Potato Association of America during the week of July 28, 1968, at Oregon State University, Corvallis, Oregon. The meetings of the Potato Association of America were held July 29 and 30. The papers presented on those days have been printed in various issues of the American Potato Journal. The papers included in this report were presented at meetings of the Potato Utilization Conference on July 30 to August 2.

Sponsors of the Utilization Research Conference were:

Oregon Potato Commission
United Fresh Fruit and Vegetable Association
Oregon State University
U.S. Department of Agriculture

As part of the program concerned with waste disposal, interested participants toured the Pacific Northwest Laboratory at Corvallis on July 31.

Statements made by participants are their own and do not necessarily represent views of the U.S. Department of Agriculture. Underscored numbers in parentheses refer to references at the end of each paper. References, figures, and tables are reproduced essentially as they were supplied by the speakers. Mention of commercial products does not imply recommendation or endorsement by the U.S. Department of Agriculture over others not mentioned.

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18TH NATIONAL POTATO UTILIZATION CONFERENCE

Corvallis, Oregon • July 30 to August 2, 1968

THE 1967 POTATO STORY - FRESH AND PROCESSED

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In developing this topic, I would like to do three things. First, I would like to establish some bearing points relative to the potato industry. In other words, I would like to establish what we know about this industry. Second, I would like to review the 1967 potato situation. Third, I would like to take a look at the future, to see what we need to know to have a sound progressive potato industry.

Some bearing points.--The potato industry has been going through a revolution in recent years. There are fewer but larger potato farms than at any time in the history of this industry. They are not only specialized, mechanized farms, but they are well integrated with contract production now commonplace. In recent years, there has been a rather marked change in the regional production pattern. For the most part, acreage has stabilized in the Midwest and East, but it continues to expand in the West. At the same time, yields are up, particularly in the West and in Oregon. Processing opportunities are now important. In some cases, processing opportunities are absolutely necessary for survival.

The potato industry has one of the highest rates of instability in both prices and income to growers to be found anywhere in agriculture. The year-to-year variation in prices received for potatoes, when compared to variations in the general farm price level, averages about 47 percent. This variation is 5 to 8 times greater than the price variation on a year-to-year basis for most field crops. Compared with meat animals, hogs have a year-to-year price variation around the general farm price level of about 16 percent; and beef cattle have a year-to-year variation of about 11 percent.

This instability arises primarily from two factors: the very highly inelastic demand for potatoes and the yearly variation in production. The demand inelasticity for potatoes is about -0.20. This means that a 1 percent change in production causes about a 5 percent change in price, inversely. Consumers want about 110-112 lbs. of potatoes per person per year regardless of the mix in

which those potatoes are purchased. It is interesting to note that recent variations in production have averaged about 8 percent per year. About three-fifths of the variation in production is caused by variation in acreage. The other two-fifths is caused by changes in yield. The potato industry is highly vulnerable to instability, caused by the large investment involved, the high cost of production, and the financial commitments necessary to bring in a crop.

In most years, the industry has had to rely upon some disposal or diversion program to bring market supplies within reasonable balance to demand. Since the 1950's the industry has seen potato supplies brought into balance with demand either through weather effects or some form of government program. The potato surplus is estimated to be about 5 to 6 percent per year. The situation is further complicated by the fact that potato surpluses are very difficult to handle.

The industry has relied upon marketing orders to provide some sort of equity in the supply-demand balance. Currently, marketing orders operate in six areas and cover about 70 percent of the late-crop potatoes. These marketing orders have been most effective in quality improvements. In addition, the United States Department of Agriculture has issued marketing guides to provide a suggested level of production which is likely to result in a realistic price. It appears that these marketing guides have had little effect on the production-marketing balance. On the average, growers have overplanted about 5 percent based upon the USDA marketing guides. In the late-crop areas, the overplant has run about 8 percent per year.

<u>The 1967 potato situation</u>.--Total potato production amounted to 305.9 million cwt. in 1967 which was slightly below the 1966 record tonnage. In 1967, however, yields averaged about the same as the 1966 record high of 210 cwt. per acre. The average production per acre in the 1961-65 period was 200 cwt. One complicating factor in 1967 was the record tonnage of fall potatoes, about 2 percent above the 1966 record.

Potato prices were relatively strong into the late summer of 1967 and began to decline as the harvest accelerated. By December the average farm price was $1.69 per cwt., nearly 25 percent below a year earlier and the lowest December price since 1963. In terms of parity prices, the December 1967 average price was at 59 percent of parity as compared to 77 percent in December '66. Idaho russet potatoes, for example, were $2.72 f.o.b. shipping point in January 1968 as compared to $4.46 a year earlier. Oregon russets in January of this year were $2.72 per cwt. compared with $5.18 a year earlier. To help relieve this low price situation, a Section 32 diversion and purchase program was initiated in January 1968.

When one begins to examine the buildup of this unfavorable potato year in 1967, all that is needed is to go back to 1964 when freezing weather brought the highest potato prices in about 40 years of record. Acreage expanded 8 percent in 1965 over 1964; another 5 percent in 1966 over 1965; and in 1967, acreage increased another 2 percent over 1966. Harvesting weather in the fall of '67 was excellent and storage losses were at a low level. As a result, the 1967 year started with about 9 percent larger stocks than were on hand in 1966. Larger stocks coupled with a buildup in production in the face of a rather constant total demand presented a troublesome situation. The result in 1967 was very unprofitable prices to growers throughout the country.

What about the future?--It seems to me that one of the most urgent needs is to find ways of reducing price instability which will contribute to improved grower returns. This industry is now big business. It is a business with high costs and high financial commitments. It requires a substantial investment. Diversion and disposal programs are not the long-run solution to this price instability. Some form of industry-managed production seems essential for the successful continuation of this industry. Studies need to be directed toward means by which the demand for potatoes can be manipulated to the benefit of this industry. Most people don't have answers to these questions. Answers will be found in very carefully directed programs of research and development by both industry and by our Land Grant Universities.

The future of this industry lies in the application of science and technology to the potato business. Processing outlets apparently hold the key to area expansion. The potato is now a raw material which is manipulated in many ways to develop new food products that will challenge the imagination of the consuming public. Undoubtedly, the development of the processing segment of your industry will continue to be the most glamorous part of the potato business. As Dean Cooney of our School of Agriculture commented in his opening remarks today, the Oregon potato industry generates about 22 million dollars of income for our state. The value added by the various processing segments, however, amounts to about 36 million dollars, which generates a total income of 58 million dollars for Oregon's economy.

If the application of science and technology to your business is to be realistic in the years ahead, your industry must contribute more private support to research and development. It seems to me that your industry has a real stake in this kind of investment. It has been estimated by some of our people at Oregon State University that investment in research can pay big dividends--as much as 30 percent on each dollar invested in research. Any member of your industry who operates his business today as he did three or four years ago is either obsolete or is on the verge of becoming

so. The biggest problem that most industries face is to keep up with the times. It is important to know what is going on. The availability of information that will "create change" in the potato business will never be as important to you or as costly to you as it will be in the future. But this is the kind of information which pays those handsome dividends and which prevents obsolescence.

THE STATE OF THE ART OF POTATO WASTE TREATMENT

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Since 1951 potato production in the United States has increased by about 50 percent. From 195 million cwt. in 1951 it has increased to almost 310 million cwt. in 1966. Much of this increase has resulted from the demand for processed potatoes, such as chips, French fries, and hash browns. Most of the increase in production during the past few years has been accounted for by four Western states, California, Washington, Oregon, and Idaho. In 1954 about 28 percent of the crop was grown in the West; now this figure is about 50 percent. Idaho alone produced 23 percent of the crop in 1966. Idaho is also a good example of the trend toward processing. In 1950, 22 percent of their crop was processed. By 1960 this figure was over 50 percent.

Waste sources and characteristics.--Both the quantity and quality of wastes produced by processing plants vary markedly. Table 1 presents some ranges for water usage, as well as the

Table 1.--Waste characteristics

	Range	Average
Water usage - gal./ton raw potatoes	2,300-7,700	4200
Suspended solids (SS) - lb./ton	25-115	60
Biochemical oxygen demand (BOD) - lb./ton	20-80	50

quantity of suspended solids and 5-day biochemical oxygen demand (BOD) generated per ton of raw potatoes processed. Water usage varies from 2,300 to 7,700 gallons per ton and averages 4,200 gallons. Suspended solids generated per ton of raw potatoes ranges from 25 to 115 pounds with an average of 60. The BOD load ranges from 20 to 80 pounds per ton and averages about 50.

The lower values of these ranges here have been reported by processing plants which have made extensive in-plant changes. These changes include: water conservation, recirculation, by-product recovery, and in-plant treatment such as screening. The importance of some of these changes is indicated by the fact that the potato peel and pulp have a BOD of about 0.1 mg. per mg. of dry solids (1). Therefore, in-plant modifications which separate the suspended solids from the liquid as soon as possible or keep the solids out of the liquid waste stream altogether will markedly reduce the dissolved organic load.

An example of the influence of contact time of potato solids with water on the dissolved BOD is shown in Table 2. Maine Russet

Table 2.--Leaching of organic material from sliced potatoes in water (2)

Mixing time, minutes	Dissolved BOD mg./liter
2.0	200
3.5	215
5.0	225
10.0	230
30.0	300

potatoes were cut into 1/4-inch cubes and 150 grams were added to 1.5 liters of distilled water. The starch liberated during cutting was also added. This accounts for most of the BOD of 200 mg./liter shown for a mixing time of two minutes. After 30 minutes of mixing, the dissolved BOD had increased to 300 mg./liter--50 percent over the two-minute value. Additional time would have increased the BOD even more, inasmuch as 10 percent of the dry weight would give about 2.6 grams of available BOD as compared to 0.45 gram actually measured after 30 minutes. If the potato pieces had been flakes or granules, the amount of dissolved BOD leached would have been considerably higher for the same weight of potatoes, since the leaching rate would be proportional to the exposed surface area.

A processing plant flow-sheet along with percentage contributions of flow, suspended solids, and BOD from each of the waste sources is shown in Table 3. This information is taken from an article by Atkins and Sproul (3) published in August 1966. The contributions shown here were measured after extensive in-plant changes were accomplished by plant management. Before these changes, water use was 2,520 gallons, BOD load 52 pounds, and suspended solids were 37 pounds per ton. The changes reduced water usage by 10 percent to 2,310 gallons, the BOD by over 50 percent to 22 pounds, and the SS by 30 percent to about 25 pounds

Table 3.--Processing plant flowsheet with waste sources (3)

Steps	Percentage contributions Flow	SS	BOD
Receiving, cleaning	1	<1	<1
Preheat	--	--	--
Lye peeling	--	--	--
Spray washing	52	97	87
Trimming	12	<1	<1
Dip tank	--	--	--
Cutting	6	<1	<1
Inspection			
Byproduct recovery	15	2	<1
Blanching	14	<1	11
Cooking, degreasing freezing, packaging	--	--	--

per ton. Following the modifications, over 50 percent of the water, 95 percent of the SS, and 85 percent of the BOD resulted from the spray washer. In fact, that was the only significant source of SS and BOD. If a dry or semi-dry peel process could replace the current process, the various contributions would be reduced to 1100 gallons per ton, 1 pound of SS, and about 3 pounds of BOD per ton of raw potatoes processed. When the capital costs and the operation and maintenance costs of secondary treatment are examined, it becomes apparent that considerable time, effort, and money can be justified to develop a dry or semi-dry peeling process.

Waste treatment.--Silt water is usually disposed of to a lagoon or a series of lagoons. Since the lagoons will fill with silt they must be periodically cleaned or replaced. Most silt is readily removed by sedimentation in these lagoons but the overflow may contain 200 to 300 mg./liter of BOD if the detention time in the lagoons is relatively short. At present this concentration is low compared to raw processing wastes or primary effluents but as secondary treatment plants are placed in operation, the effluent from silt ponds may contain a higher concentration of BOD than the secondary effluent. At that time additional treatment of some silt pond effluents will probably be required.

Odor problems may be encountered with silt ponds during periods of shutdown. There is usually enough suspended organic material in the silt water to cause anaerobic conditions to occur in ponds. This may be taken care of by pumping fresh water or river water, if available, through the pond during nonproduction periods. Small floating surface aerators could also be used to supplement available oxygen.

Preliminary.--The most widely used method of removing large pieces of potato material is screening with mechanical vibrating screens. Screen sizes are usually in the 10 to 40 mesh range. Reduction of both suspended solids and BOD usually ranges from 20 to 40 percent. Solids content of the screenings range from 5 to 10 percent. In Idaho these screenings are usually fed to cattle. Some plants have had troubles with blinding of the screen but this can be controlled by steam cleaning several times a day.

Primary.--Primary sedimentation, either in circular or rectangular sedimentation basins, is the single, most widely used treatment process by the potato processing industry. Gravity separation is used to remove suspended solids along with their associated BOD. Reported efficiencies vary considerably from plant to plant, but BOD removals of 40 to 60 percent and suspended solids removals as high as 90 percent can be obtained. Typical overflow rates range from 500 to 1000 gallons per day per square foot of surface area.

Without automatic controls or close supervision over manual sludge withdrawal, problems of rising sludge may occur in the primary sedimentation tanks. Similar difficulties have also been experienced in tanks without mechanical sludge scrapers.

Secondary: Trickling filter.--A trickling filter consists of a tank which usually contains rock. The rock provides a large surface area for attachment of the organisms over which the sewage or waste is "trickled." As yet no full-scale trickling filtration plants have been built, although some pilot plant work has been done on potato wastes with Dow Chemical Company's Surfpac (4). This is a trickling filter which contains artificial media in place of rock. It has a much higher surface area per unit volume than rock, in addition to a larger percentage of voids. The media are much lighter, but also more expensive. BOD reductions of 50 to 75 percent were obtained at loadings of 400 to 600 lbs./1000 $ft.^3$/day with recycle rates of from 2.5 to 1 to 7 to 1. Both nitrogen and phosphorus additions were required to make up for deficiencies in these essential inorganic nutrients.

Activated sludge.--In an activated sludge system the organisms are suspended in a tank with the waste to be treated. Air is introduced near the bottom of the tank to keep the contents mixed and to maintain aerobic conditions (presence of oxygen). The suspended organisms are called mixed liquor suspended solids (MLSS). As with trickling filters, activated sludge treatment of potato wastes has not been practiced on a large scale as yet. Full-scale plants are currently being designed and built.

During the past 5 to 6 years several investigations of this process have been made with bench-top and pilot-plant-sized facilities. This work has been done on effluents from both lye-peel and steam-peel plants with several modifications of activated sludge. Reported BOD reductions ranged from 50 to over 95 percent, depending upon the type of activated sludge process, loading, nutrient addition, pH adjustment, etc. Atkins and Sproul (3) obtained BOD reductions greater than 95 percent with a completely mixed activated sludge system. These were obtained on wastes from a lye-peeling plant without pH adjustment, a MLSS level of 4,000 mg./liter and a detention period of 6 to 8 hours.

Cornell, Howland, Hayes, and Merryfield (4), Consulting Engineers, Corvallis, in cooperation with the Potato Processors of Idaho Association, obtained 86 and 92 percent reductions in complete mixed systems at detention times of 10 and 20 hours, respectively. Mixed-liquor suspended solids averaged 1300 and 3,000 mg./liter, respectively. Contact stabilization, a modification of activated sludge, was also investigated on a pilot-plant scale. BOD reductions of about 50 and 60 percent were obtained with a loading of 500 lbs. BOD/1000 cu. ft./day, one-hour contact time, and 6 and 10 hours of sludge reaeration.

At the higher loading, both complete mix and contact stabilization modifications may produce excessive foam for which a defoaming agent may be required. It appears that pH control will not be necessary but some individual plants may require addition of inorganic nutrients: nitrogen and phosphorus.

Aerobic ponds.--Results from full-scale as well as pilot studies indicate that aerobic pond loadings should conform to conventional design criteria. For domestic sewage, the loadings range from about 30 to 100 lbs. BOD/acre/day, depending on local climatological conditions. A plant processing 500 tons of potatoes per day, for example, would require 500 acres of land for standard stabilization ponds at a loading to 50 lbs. BOD/acre/day.

Anaerobic treatment.--Anaerobic treatment, using deep ponds or closed tanks, is sometimes substituted for primary and secondary treatment. Anaerobic means "without air" and the anaerobic organisms break down organic matter without requiring dissolved oxygen in the waste. The process requires operational surveillance, maintenance of higher temperatures for optimum treatment, and care in the collection and disposal of odorous gases given off during treatment.

Land disposal.--The use of land disposal of potato wastes by spray, ridge, and furrow or other type of irrigation has been

used very little. In many areas where land is available this method of disposal offers an economic solution. There are two primary areas of concern. First, these systems should be designed and operated so that the waste stream is treated as well as disposed of. Ground water pollution can be more serious than pollution of surface waters, because ground water does not have the self-cleansing ability that most surface waters have. The second area of concern is the disposal of lye-peeling wastes by this method. The sodium content of these wastes will cause the soil to become impermeable by replacing the calcium and magnesium in the soil colloidal structure. The United States Department of Agriculture (5) classifies lye-peeling wastes, whether treated biologically or not, as unsatisfactory for irrigation purposes.

This same potential problem can arise when a lye-peel waste is discharged to a small stream which is used for irrigation purposes. The sodium content of a waste stream is virtually unchanged by any of the treatment processes discussed today. Here is another very good reason for continuing the work on the development of other methods of peeling potatoes.

Odor control.--Dr. Carlson, University of Washington, has conducted laboratory experiments using soil filters for stabilization and removal of objectionable gases (1). Passage of odorous gases from anaerobic ponds, trickling filters (if necessary), pumping stations, etc., through a minimum amount, perhaps six inches, of soil under controlled conditions should provide odor control with low maintenance costs. This type of odor control has been used for over five years to handle odor problems from a pumping station on Mercer Island, Washington.

Sludge handling and disposal.--The solids concentration of the sludge from the primary clarifiers has been found to vary considerably with method of peeling and the operation of clarifiers. A plant using caustic peeling and allowing the sludge to ferment biologically in the primary clarifier until the pH has been lowered to around 6 may get a solids concentration of 5 to 7 percent in the sludge from the primary clarifier. Plants using steam peeling may obtain 5 to 6 percent solids in the underflow.

Poor design and operation of the primary clarifier may yield a solids concentration in the sludge of 1 percent or less. This will increase required pump sizes and also increase power costs by about a factor of five.

Further dewatering of the sludge is usually done with either a vacuum filter or a centrifuge. A centrifuge will thicken the sludge to a solids level of 15 to 20 percent and the centrate containing 2 to 4 percent solids should be returned to the primary clarifier influent. A continuous-belt vacuum filter will do a

more efficient job of removing the solids but the filter cake will contain slightly less solids, usually in the 12 to 15 percent range.

The thickened sludge from either one of these processes, along with screenings from the vibrating screens, is then sold for cattle feed. Cattle will accept up to about 25 percent of their total diet in this form. This material has a value as cattle feed of 2 to 3 dollars per wet ton in Idaho.

Inasmuch as there are no full-scale secondary treatment plants treating potato wastes, no information is available on the handling and disposal of secondary sludge. It is not anticipated that sludges produced by activated sludge, trickling filtration, or other types of secondary treatment of potato wastes would be much different from similar sludges from other industrial and domestic-waste secondary-treatment plants. In these other areas considerable information is available on methods and costs of handling and disposal of sludge.

One avenue that needs further exploration is the combining of thickened secondary sludge with the screenings and primary sludge and feeding of this combination to cattle. As yet it is not known for sure how much secondary sludge can be added before the combination is rejected. If most of the secondary sludge could be disposed of in this fashion, it could markedly influence the type of secondary-treatment process used. There is also the possibility of drying these sludges separately or in combinations and using the product for pet food.

FWPCA program.--The Pacific Northwest Water Laboratory of the Federal Water Pollution Control Administration in Corvallis, Oreg., has been assigned national responsibility for food processing wastes. In each of the major food processing areas, such as potato, the waste treatment research needs will be developed and these needs will be given priorities. The total problem will be attacked systematically from three directions. First, the FWPCA will do some in-house research. Second, research grants, contracts, and demonstration grants will be awarded to various universities, industries, and other groups to work on designated problems. The third, and not least, will be work done by industries and groups such as the Potato Processors of Idaho Association.

During the past two processing seasons our laboratory has been working jointly with this Association and the Idaho State Department of Health on pilot plant studies on secondary treatment of potato processing wastes. One progress report was published (6) about seven months ago and a final report should be available sometime this fall. In this work the first of three

small lagoons was operated as a surface-aerated, aerobic cell. It was fed primary clarifier effluent and it functioned as an activated sludge system with zero sludge recycle. The second cell was also fed primary effluent, but it was operated as a covered, complete-mix, anaerobic unit. Overflow from this pond passed to a third pond which was also a completely mixed surface-aerated unit. Data obtained during the past two seasons from these ponds have not been completely evaluated as yet but some preliminary conclusions can be made.

1. A five-day BOD reduction of over 80 percent can be obtained by primary clarification plus either an aerobic lagoon or anaerobic-aerobic lagoon in series.

2. Secondary clarification of the lagoon effluent for removal of suspended solids will be required in most cases.

3. Covering of the anaerobic lagoon will reduce the temperature drop during cold weather and also help control odors.

4. Preliminary cost estimates indicate that a combination of anaerobic-aerobic lagoons in series may result in lower total annual costs than either anaerobic or aerobic treatment separately.

This coming processing season (1968-69) the Idaho Potato Processors Association will be continuing its work on secondary treatment of potato wastes on a pilot plant scale.

The FWPCA has also awarded several grants which will assist the total effort on treatment of potato processing wastes. The University of Washington in Seattle, Washington, was awarded a grant to develop a report on the "Status and Research Needs for Potato Waste Waters." This will be done under the direction of Professor D. A. Carlson. Besides a description of the problem, both the present and future magnitude of the problem will be discussed along with current research and development efforts by various municipal, State, and Federal agencies, universities, industries, and other domestic and foreign organizations. Current and proposed technology will be covered and a technical evaluation will be made of the work which has been done. Research needs will be itemized and methods suggested for filling these needs, including level of effort in manpower and dollars, and modes of effort: either in-house, contract, or grant. This document is scheduled for completion by May 31, 1969.

The R. T. French Company in Shelley, Idaho, has been awarded a research and demonstration grant on "Aerobic Secondary Treatment of Potato Processing Wastes with Mechanical Aeration." FWPCA has funded this project in the amount of $483,217 out of an estimated total cost of over $700,000. The objectives are the establishment of design criteria, construction and operating costs for aerobic biological treatment of potato processing wastes. Two activated sludge systems using surface-aerated basins will be operated at varying loads and their efficiences determined.

Secondary sludge handling and disposal will also be investigated. This facility should be in operation by the first of the year in 1970 and will operate for one processing season prior to completion of a final report.

The city of Grand Forks, North Dakota, has just been awarded two grants. The first is about $59,000 to assist in building four 8-million-gallon lagoons, plus auxiliary pumps, piping, etc., to operate these in various combinations. Two will be anaerobic and the other two will contain surface aerators. The second grant is a research and demonstration grant of $390,000 to monitor the operation of this facility for a period of one and a half years. The waste to be treated consists of domestic plus the effluents from four potato processing plants. Throughout the year the contribution of BOD from the potato processing plants will vary from zero to over 50 percent of the total waste load. This project should answer some of the questions concerning advantages and disadvantages of joint treatment as compared to the separate industrial waste treatment at the Shelley plant.

In addition to these grants, Vahlsing, Inc. in Easton, Maine, has been awarded a research and demonstration grant of $280,000. The feasibility of using activated sludge to treat combined potato and sugar beet wastes with pilot plants will be checked. The effect of the combined waste upon a residential waste system will also be determined.

Conclusion.--In conclusion, a brief rundown of the status of treatment of potato processing wastes has been given along with some ideas of what is planned for the near future. The importance of individual plants doing as much as possible to eliminate or reduce the wastes at their source cannot be overemphasized. Costs of secondary treatment are such that a large amount of time, effort, and money can be expended on inplant modifications, including inplant treatment and reuse. Costs and efficiencies of primary treatment have been fairly well established and similar data are currently being generated for secondary treatment. Tertiary treatment may be next.

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"DRY" CAUSTIC PEELING OF POTATOES

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Recent Federal, State, and local rulings concerning the pollution of streams and waterways have emphasized the necessity to investigate means of removing organic materials from plant waste waters, and also to investigate processes which introduce these materials into the waste waters. Potato peeling is a process that introduces large amounts of organic material into potato processing effluents. At our laboratory in Albany, Calif., we have been studying a new approach to potato peeling that is designed to keep most of the peeling material out of the plant effluent. The approach attempts to remove the peel material and the alkali in a dry or wet handleable form before the potato is placed in water. This material may then be burned, buried for land disposal, or possibly fermented and fed to cattle in a mixed feed. We call this system "dry" caustic peeling.

It has been estimated that up to 80 percent of the organic material in the plant effluent comes from the peeling process. Dry caustic peeling might keep 95 percent of this organic material out of the plant effluent.

Studies have been made on individual potatoes impaled on spits and in a 500-pound-per-hour continuous plant. The basic peeling system comprises several steps: (a) contacting room-temperature wet-washed potatoes with hot dilute lye solution, (b) draining the excess lye and allowing the potatoes to stand at ambient temperature, usually for 5 minutes, (c) heating with gas-fired infra-red burners, (d) peeling on rubber-tipped rotating rolls, (e) immersing in water and finishing in a barrel or brush washer with water.

Oregon and Idaho Russet potatoes stored for various periods were used in all experiments. Most of the tests on individual potatoes were made with U.S. No. 1 grade to minimize variations due to cut surfaces and other damage. Potatoes weighing about 10 oz. were selected to minimize variation for the individual tests. Both No. 1 and No. 2 potatoes of varying sizes were used in the 500-pound-per-hour continuous plant.

Experiments were made on individual potatoes on spits using 170°F. lye at 13, 17, and 20 percent concentrations. Peeling losses were measured by weighing the initially washed potatoes before and after peeling.

Lambert gas-fired infra-red heaters obtained from the Lillard Co. of Walnut Creek, Calif., and operated at 1550° to 1600°F. were used for heating. Tests on individual potatoes that were continuously rotated under the heaters indicated that about one minute was adequate for peeling. In the 500-pound-per-hour plant, eight burners heat the potatoes in a 5-ft.-long by 38-inch-diameter rotating barrel with 3/4-inch perforated walls (fig. 1). The rotation of the barrel causes the potatoes to rotate and to move in and out of the radiation field of the heater. The action of the perforated barrel also causes about half of the peel solids to be abraded off the potato during the heating process. Residence time in the barrel varied from 2 to 5 minutes and was longer than the time established for continuous heating. Peel material abraded off the potatoes in the barrel was usually about one-half of the peel solids removed from the potatoes. This material dried and dropped through the perforated barrel. The rest of the peel was removed without use of water on rotating steel drums covered with a rubber sheet having half-inch-long projections. This material, called Type SCM Scrubber Matting, was obtained from the Holz Rubber Co., Lodi, Calif.

After peeling, the potatoes are placed in water to remove a small amount of residual heat and about 1/2 percent of soft semi-sticky residue. Variations in peeling loss from 6 to 20 percent have been obtained, principally by varying the caustic dip time.

Figure 1. Pilot dry caustic peeling operation.

Several variations in peeling technique are possible with this type of equipment. These variations would probably be dictated by the use or method of disposal of the peel material.

A belt-type live roller conveyor is being purchased and will be tested to evaluate peeling with a continuous shorter irradiation time. Under these conditions all of the peel material would be removed by the rubber tips and the residue would have a solids content of about 18-20 percent.

EDIBLE ALGAE FROM POTATO WASTE

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The possibility that micro-algae could be produced on potato processing wastes was suggested during an earlier presentation by one of us before the potato industry at Sun Valley in 1963 (1). At that time, however, there was no information to indicate whether or not algal growth on potato wastes is a feasible concept, and indeed it was unknown if algae cultivation could be practiced economically with any waste but sewage. In the intervening five years, algae culture studies have been extended to include beet sugar flume wastes, Steffens waste, and chicken manure, and two studies have been made on growing algae in potato wastes. The first involved the potential of potato wastes to support algae in an aerobic system and the second involved anaerobic fermentation of potato wastes as a step toward algal growth.

In addition, our brief review of the literature on potato waste disposal has indicated that the industry has accomplished extensive meaningful research since 1961, and that application of available information would go far toward solving the potato waste problem. By-product recovery has been accomplished in settleable solids screening (2) and in yeast production (3). However, much work has been directed toward waste destruction rather than by-product recovery. Thus, further work on by-product recovery is indicated.

Algae production could theoretically yield large quantities of autotrophic organic matter. This paper sets forth fundamentals probably related to production of edible algae from settled potato processing wastes and reviews our brief research on this subject. We regard the work cited here as preliminary and, therefore, subject to revision. Our results are, however, sufficiently encouraging that the subject should be introduced to the potato processing industry, so that additional work can be supported should the opportunity arise.

From a practical standpoint, studies at the University of California and elsewhere on micro-algae culture have continued to be favorable (4). Large-scale cultures continue to increase in size and to be more widespread in their application. Algae meal is produced for sale by the University of California project in Richmond, Calif., and large-scale cultures are being applied for oxygen production and nutrient stripping. In the 20 years since

large-scale algal culture began, a scale-up in culture volumes of about 8 orders of magnitude has been attained. A scale-up of 8 additional orders will require widespread industrialization of micro-algae cultures. There is already evidence that such industrialization is occurring. For example, algae culture is being studied as a method of treating agricultural drainage, and a plant which would require more than 5,000 acres of micro-algae ponds is already at the pilot plant stage in connection with the California Water Plan (5).

Uses of micro-algae are also increasing. Since it contains 50 percent protein, waste-grown algae were originally conceived as a protein supplement for cattle, sheep, and swine. Instead, dehydrated algae from our pilot plant have been subjected not only to use as animal feed but to vitamin and amino acid extraction and have been used to feed shrimp larvae, fish, and oyster spat. Indeed, the application of algae in oyster spat culture appears to be economically feasible at this time in spite of the fact that the current price of dehydrated algae is $2 per pound f.o.b. Richmond.

The work with cattle, sheep, and swine conducted by Drs. Hintz, Weir, Heitman, Torrell, and Meyer at the University of California at Davis (6) has been extremely encouraging. In fact, the original concept that algae are a protein supplement equivalent to soybean meal for swine has been revised upward (7). Dr. Hintz has found that algae supplemented with a small amount of vitamin B_{12} and fed at 10-percent level pelletized with barley gave growth equal to the growth of swine fed fish meal in barley. The animals were also equally as good when slaughtered. Thus it appears that micro-algae meal should be worth as much as 8 cents per pound dry weight as a swine protein supplement.

Production costs for algae are currently $2 to $3 per pound in the 2/3 acre pilot plant at Richmond, but this is based on production 6 hours per day and less than 50 percent of the time. If a steady rate of production could be attained in Richmond, we could produce algae now for less than $1 per pound. Extropolation to plants of 100 or more acres indicate that an ultimate production cost for waste-grown algae of 3 cents per pound or less. In theory at least the production of algae from wastes will always be more economical than production from specially prepared inorganic media, not only because the raw material is essentially free but because the waste must be treated anyway.

In examining the literature on potato wastes, we have found little concern to date for the problem of plant nutrients (8,9). As is now well known, carbonates, nitrates, phosphates, and other oxides are produced in the bacteriological decomposition of all wastes including those from potato processing. In the national

planning committee of today, there is grave concern regarding the effects of uncontrolled algae growth resulting from the presence of excessive amounts of such nutrients in receiving waters (10). It seems likely that in the foreseeable future, wastes which result in nitrogen concentrations in excess of about 1 mg. per liter and phosphorus concentration in excess of 1.0 mg. per liter in the natural environment will be barred from many receiving waters. Thus, industries already faced with the serious problem of oxidizing their wastes will also be required to remove the products of organic oxidation from their effluents. It is quite likely that the potato processing industry will not be an exception.

It is worthwhile now to examine the fundamental process of algal culture on waste. In the symbiotic algal-bacterial process, waste organic matter is introduced into a system where bacterial oxidation is under way. Bacteria oxidize the organic matter to ammonia, carbon dioxide, and other end-products. Algae growing in the same or in a contiguous reactor, and energized by light, take up the products of oxidation, forming algal cell material and releasing oxygen. Thus waste material is converted to new, energy-rich and protein-rich organic matter in the form of algae. If the algae are removed from the system, the remaining water is not only low in BOD but is to some extent depleted of plant nutrients as well. Conventional waste disposal systems have always dealt with optimization of the bacterial portion of this process and ignoring the algal half, whereas in controlled photosynthesis, both halves of the process are of concern.

Before permitting you to gain an overly optimistic view of the algal-bacterial process, it is essential to point out its limitations. Algae growth is fundamentally a slower process than bacterial growth. Thus the process in its elementary form is always limited by the rate of algae growth and oxygen production. This implies that the algae must obtain a nutrient intake suitable for their growth from the waste decomposition and that light should not limit the energy requirements of their growth. In the case of domestic sewage, a balance exists which permits organic loadings up to 400 lb. of BOD per acre per day in mid-summer (latitude 37°) but only 100 lbs. per acre per day in winter (11). Supplementary aeration has been found to be extremely beneficial in the case of beet sugar flume water which tends to turn black when it is anaerobic. This black color excludes light from the algae, but with beet sugar flume water and domestic sewage, the upper limit for photosynthetic oxygenation with supplementary aeration is on the order of 600 lbs. BOD per acre per day in summer and 200 lbs. in winter. Since mixing is vital in the large-scale cultivation of algae, supplementary aeration is to some extent accomplished during the mixing process.

Because of extreme variations in waste strength and flow and in the large amounts of land involved in areal loadings, the more efficient anaerobic pond is employed in sugar beet waste treatment (12). Anaerobic ponds are constructed 12 to 15 feet deep and should be loaded not to exceed 2,000 lbs. of BOD per acre per day when the waste BOD is 1000 mg. per liter. When the loading is 2,000 lbs. per acre per day, BOD removals on the order of 70 percent are attained and the effluent BOD is brought to strengths within the treating capability of the photosynthetic system, i.e., to less than 400 lbs. of BOD per acre per day. In beet wastes, odors are controlled by supplementary surface aeration in the anaerobic pond while in the algae pond no odors are produced. The BOD from the algae pond is usually less than 50 mg. per liter and often as low as 20 mg. per liter when vigorous algal growth is attained.

Experimental.--The major characteristics of domestic sewage, beet sugar flume water, standard inorganic algae pilot plant media, and a typical potato processing waste are presented for comparison in Table 1. It is evident that potato wastes are generally stronger

Table 1.--Comparison of domestic sewage, beet flume water, and potato waste with standard algae nutrient

Characteristics	Domestic sewage	Beet sugar wastes (12)	Standard algae pilot plant (16) (inorganic)	Potato wastes (14,15)
Total solids	800	3000	6250	4000
Volatile	500	1500	--	2500
Total N	60	50	315	180
Organic N	28	20	--	170
Ammonia N	30	30	--	10
Nitrate N	2		315	1
Phosphorus (P)	20	5	300	20
Sulfur	8	100	300	--
Potassium	12	80	1690	100
Alk. mg./liter as $CaCO_3$	200	500	--	
5-day 20°C. BOD	350	1000	00	2500
pH	7-8	9-11	6	9-11
Magnesium	18	--	492	
Calcium	7	--	15	
Trace minerals	Pres.	Prob. pres.	Must be add.	Prob. pres.

than beet sugar wastes and contain much more nitrogen and phosphorus. In potato wastes, the carbon, nitrogen and probably the phosphorus are at first in an organic form unavailable to algae without prior bacterial decomposition. Bacterial decomposition on the other hand will be limited by the high pH of the waste until production of CO_2 or organic acids reduce the pH.

Based upon the nitrogen present, the algal growth potential of the potato waste in Table 1 is 1,800 mg. per liter and (AGP) algal growth potential based on phosphorus is 2,000 mg. per liter. Based on the BOD there is sufficient carbon in the waste to yield an algal crop of about 1,500 mg. per liter of waste. Thus, it appears that carbon may limit algal growth in some potato waste. Since potato wastes are of organic origin, it is logical to assume that all trace elements are present although this could be erroneous if precipitation of polyvalent metals were to occur due to the high waste pH. It was of course not possible to speculate regarding the biological availability of potato wastes for algae; hence, experimental work was required. Bioassays were the major method applied.

The assays were carried out in accordance with procedures for AGP determinations, which are currently under standardization by a national committee (13). Essentially, our tests involved serial dilutions of the waste with water and inoculation of the dilutions with bacteria and algae. The inoculated samples were then incubated in the light and at temperatures such that bacterial and algal growth occurred freely. The tubes were mixed and sniffed daily for odor. If found to be odorous, the indication was that algae growth in the dilution at hand was insufficient to meet the oxygen demand of the bacteria at that time. In samples that were fresh-smelling, the algae were evidently meeting the oxygen demand of the bacteria. At the end of the incubation period indicated by no increase in algae growth, and in this case in 10 days, the dry weight of algae was determined and its oxygen equivalent compared with the BOD. The oxygen equivalent or theoretical oxygen production (TOP) was computed by multiplying the algae concentration (C_c) by 1.6.

A typical experiment is shown in Table 2. Based on the nitrogen and phosphorus in the waste used, the AGP of the waste

Table 2.--Photosynthetic oxygen production in potato waste[a/]

No.	Algae ml.	Water ml.	Potato waste ml.	BOD+ mg./l.	C_c++ mg./l.	TOP+++ mg./l.	TOP/ BOD
1	2	0	100	1980	--	--	--
2	2	50	50	990	875	1400	1.42
3	2	66	33	660	800	1270	1.89
4	2	85	16	396	437	700	1.76
5	2	91	9	200	138	220	1.10
6	2	98	2	40	50	80	2.00

[a]N = 150 mg./liter. P = 12 mg./liter. + Based on 60 percent depletion of O_2. ++ Conc. of algae in mg./liter. +++ TOP = theoretical oxygen production.

was 1500 mg./liter for N and 1200 mg./liter for P. Based on the actual AGP attained, the 50 percent dilution produced 875 mg./liter of algae. Thus, it appears that following bacterial action, most of the nitrogen and phosphorus became available to algae and in addition algae growth was stimulated to an extent wherein the actual concentration of nitrogen in the cells fell below 10 percent and the concentration of phosphorus in the cells fell below one percent. For example, assuming that phosphorus was a limiting factor in the test, the ratio of phosphorus in the cells must have been 600/875 x .01 = .0069 percent. A shortage of phosphorus in the waste would account for the decreased TOP/BOD ratio in the 10 percent dilution (exp. no. 5).

It is significant that in all cases where growth occurred the TOP/BOD was greater than 1. Failure of algae to grow in the undiluted waste in this test was attributed to an extensively high pH for bacterial action. However, at the end of 10 days, some green was showing in the flask and after 20 days, it too was green. It was concluded that a stronger inoculum of algae adapted to potato wastes might grow rapidly in pure potato waste with adjusted pH. This was found to be the case. Accordingly, algal cell material from previous growth experiments was conserved and used for inoculum in ensuing experiments. This proved to be practical since adapted algal seed was found to grow very rapidly in full-strength potato waste.

The possibility that phosphorus or pH limited the growth of algae on potato waste was tested by assays similar to those described above. Growth in pure waste following phosphate addition and carbonation was to be compared with growth in the pure waste attained in a 1:1 dilution. The pH of potato waste was found to be lowered from pH 10 to 6 by bubbling CO_2 through the waste for two minutes. The rate of bubbling was about 0.2 SCUF pure CO_2 per minute in a 1-liter vessel of waste. After the waste had attained a pH of 6.0, triplicate flasks were inoculated with 5 ml. of adapted seed and incubated for 8 days. The mean growth is shown in Table 3.

Similarly in testing the effects of phosphate addition, H_3PO_4 was added to give a final concentration increment of 8 mg. per liter of available phosphorus as P. Again, triplicate samples were incubated and the concentrations of algae determined as a function of time. Mean growths are shown in Table 3. To further test the efficiency of 1:1 dilution of the potato wastes in tap water, triplicate samples were made up and incubated as above. The concentrations of algae are shown in Table 3. The results show that algae grow vigorously in raw undiluted potato waste if either phosphate is added at the 8 mg./liter level, if carbonation is applied, or if the waste is diluted 1:1. In each case the

Table 3.--Concentration of algae (C_c) and theoretical oxygen production (TOP)[a] under phosphate addition, carbonation, and dilution in mg./liter (inoculum 5 ml. algae)

Time	100 ml. PW 8 mg./l. P	100 ml. PW CO_2 to pH 6	50 ml. PW 50 ml. water
days	C_c	C_c	C_c
1	490	250	210
2	840	512	420
3	1090	700	615
4	1340	870	755
5	1470	1060	850
6	1540	1230	880
7	1580	1400	910
8	1600	1520	910

[a]To obtain theoretical oxygen production, multiply C_c x 1.6.

8-day growth represented a theoretical oxygen production greater than the BOD of the waste. Early in the test some odors occurred but these became negligible by the third or fourth day. The TOP/BOD ratio was 1.3 for phosphate addition, 1.23 for carbonation, and 1.46 for dilution. Thus, although carbonation and phosphate addition resulted in higher growth rates, simple dilution resulted in superior oxygenation and a shorter period of odor production.

We conducted a study of odor emission concurrently with all other tests. A more precise experiment was subsequently conducted. To assure that odor-forming organisms would be present, a weak domestic sewage having a BOD less than 100 mg./liter was used as dilution water (Table 4). As is evident from the table, odors persisted in the concentrated wastes up to 7 or 8 days, whereas the 1:1 diluted waste became odorless in about 4 days. The indication here is that in any system, detention periods of at least 5 days should be used and treated waste should be recycled at least 1:1 in order to avoid odors.

Details of our studies of the anaerobic fermentation of potato wastes will be reported in a future paper. Preliminary results indicate that although potato wastes are subject to methane fermentation, extended continuous fermentation will not sustain itself without provisions for pH and odor control. Thus, in any system in which anaerobic fermentation is applied to pretreat potato wastes for subsequent algal growth, recirculation and dilution of the waste with buffered final effluent water would be desirable.

Table 4.--Odor endurance in various dilutions of potato wastes in domestic sewage

Sewage	Potato waste	Algae seed	Days 1	2	3	4	5	6	7	8	9	10
Ml.	Ml.	Ml.										
90	5	5	+	+	0	0	0	0	0	0	0	0
85	10	5	+	+	0	0	0	0	0	0	0	0
80	15	5	+	+	-	0	0	0	0	0	0	0
75	20	5	+	+	+	0	0	0	0	0	0	0
70	25	5	+	+	+	0	0	0	0	0	0	0
65	30	5	+	+	+	0	0	0	0	0	0	0
63	35	2	+	+	+	-	0	0	0	0	0	0
58	40	2	+	+	+	+	0	0	0	0	0	0
53	45	2	+	+	+	+	0	0	0	0	0	0
48	50	2	+	+	+	+	-	0	0	0	0	0
43	55	2	+	+	+	+	0	0	0	0	0	0
38	60	2	+	+	+	+	0	0	0	0	0	0
33	65	2	+	+	+	+	+	0	0	0	0	0
28	70	2	+	+	+	+	+	0	0	0	0	0
23	75	2	+	+	+	+	+	-	0	0	0	0
18	80	2	+	+	+	+	+	+	0	0	0	0
13	85	2	+	+	+	+	+	+	+	0	0	0
8	90	2	+	+	+	+	+	+	+	0	0	0
3	95	2	+	+	+	+	+	+	+	-	0	0
0	100	2	+	+	+	+	+	+	+	0	0	0

<u>Discussion</u>.--From the preliminary data presented here, it is evident that the potato wastes studied are superb nutrients for algal culture and that a system could be designed in which algae would provide all of the oxygen required for oxygenation and complete treatment. If the entire algal growth potential of the waste were exerted, production would be on the order of 1,200 mg. per liter or about 5 tons per million gallons of waste processed. At 5 cents per pound, the value of such algae would be on the order of $500 per million gallons processed.

To obtain such quantities of algae, a completely controlled system would be required and could be obtained only with a substantial capital investment. The problems of inclement weather would have to be compensated and complete mixing of the system would be required. However, it seems likely that if a high use of algae could be found, such an investment would be justified. There is a new system for growing algae in greenhouse fashion and it remains to be seen whether such a complex system would be justified for by-product recovery from potato wastes. One such system is the algatron (18) in which cultures of algae as dense as 6 grams per liter can be produced in as little as 12 hours' detention period. If such systems could be justified economically, there is little

doubt that complete in-house treatment and reclamation of potato wastes could be attained essentially independently of weather.

The beneficial effects one might hope to attain would be an improved effluent, reduced aeration costs resulting from economic production of oxygen, reduction in odors of holding ponds, production of by-product algae, and nutrient stripping. Theoretically at least use of a waste for algae production is comparable to use of wastes for irrigation of crops with two exceptions. Algae production per unit of area is 10- to 20-fold that of crop production, and with algae production, most of the water is not consumed and hence can be used for irrigation directly, or reused in the plant following algae removal. From a production standpoint, intensive algae culture on potato waste would yield algae aesthetically suitable for human consumption and possibly commanding a price in excess of that anticipated for the sewage-grown product, which is aesthetically and epidemiologically unfit for human consumption.

A major deterrent to growth of algae on potato wastes is climate. Potato production in northern latitudes from mid-September to early May bridges the winter months when algae growth is most limited. Thus algae culture on potato wastes must be applied during early fall and late spring, with alternate methods used during the winter, or the wastes must be stored for processing during the summer. An alternative is greenhouse culture systems applied the year around. The latter would be expensive and hence only economically feasible if a very high use for algae could be found. A typical high use could be as health food or vitamin or hormone production or as a special condiment or spice. Our estimates indicate that the cost of greenhouse algae production would be 20 to 30 cents per pound--far above that in outdoor ponds. Since the algae would be a pure by-product of a vegetable processing system, they might command a price of 50 cents per lb. on the open market which would offset this high production cost. The benefits of waste treatment, nutrient stripping, and water recovery would also accrue to the industry if greenhouse culture were practiced.

Conclusions.--The results reported here indicate that large quantities of edible algae can be produced from potato wastes concurrently with complete oxidation of the waste and removal of algae nutrients. More intensive investigation of the kinetics of algae growth in potato wastes should be carried out in the near future.

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AN APPROACH TO THE SOLUTION OF THE POTATO STARCH FACTORY WASTE PROBLEM

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The will to survive, public outcry, government edict, and a certain amount of common sense have finally led us to a point where the problems of waste disposal and water and air improvement are beginning to receive attention. On a total national basis, the amount of waste produced by starch factories is a drop in the bucket, but it constitutes an extremely high loading to the stream in areas where starch is produced. It is, therefore, important that ways and means be found for treating it.

Every change in established methods of doing anything important requires scrafices by some for the good of all. If cost of disposing of protein water is passed on to the consumer, the consumer must pay more for the starch. If the cost is absorbed by the manufacturer, he must accept a lower profit. The starch industry is in a squeeze since it is already working, in most cases, at a low margin of profit and, therefore, it cannot

absorb all of the cost. Also, potato starch factories cannot raise prices very much because of competition from other starch sources less affected by such problems.

In order to lessen, and possibly distribute, the burden of disposal costs, our Division has embarked upon a series of studies directed at the possible economical recovery of certain possibly valuable compounds from the protein water effluents of these starch plants. Requests for information concerning our plans led us to the presentation of this paper.

The backgound reasons for such a program are interesting. For many years it was thought that water was unlimited and that pollution of streams and lakes and even coastal waters would have no effect on the future. However, we now know that the supply of water is fixed within narrow limits. It is also known that, as industry, agriculture, and population expand, the demand will surpass the supply. This fixed supply, however, is always in some phase of the natural water cycle. Water falls on the earth from the atmosphere. It then evaporates back into the atmosphere, runs into our rivers and thus into the oceans, or it seeps into the earth. This latter water replenishes the underground water and returns to the atmosphere by evaporation from the soil or is transpired by vegetation. Pollution at any point in this cycle reduces the useful water available and narrows the gap between the total available water and that required by the economy.

Government and industry are learning how to manage at least part of this cycle by flood control, weather control, desalination of brackish and salt water, reuse by cycling in the processing plants, pollution control and renovation of already polluted water. Our planned efforts are aimed at alleviation of the problem of pollution and, thereby, at lessening the problem of renovation.

To give you an idea of the magnitude of the problem in only the potato starch industry, a few statistics might be helpful. Estimated precipitation on the United States is 4.3 trillion gallons per day. When we subtract the amounts lost by evaporation before it can be used, by flooding, and that used by navigation, fish and wildlife, the estimated water available for use in 1965 was 315 billion gallons per day. That same year we used 356 billion gallons per day, which was possible only because of reuse. It is estimated that, by 1975, our requirements will be 450 billion gallons per day, which amounts to an annual average increase of 2.4 percent. It can also be estimated that the starch factories in three States will produce protein water in volumes of about 3 to 5 million gallons per day at an estimated BOD content of 2500 to 9000 mg./liter. Since they are in a relatively restricted area, continued dumping into rivers and streams will make reuse of this water impossible. If this pollution is added to all other industrial and civic pollution, it can easily be seen

that we will no longer have the difference between the 315 billion gallons per day available in 1965 and the 450 billion gallons required by 1975.

It is difficult to think in terms of millions and trillions of gallons. Therefore, let's limit our thinking, for a minute, to just the starch plant problem. The BOD of potato protein water varies from 2500 to 9000 mg./liter depending upon the processing methods employed and the manner in which water is used in a specific processing plant. This is a relatively high loading when compared to many other industrial wastes and the solids are relatively difficult to treat. The cost of secondary treatment facilities for removing even 85 percent of this BOD by present methods has been estimated at a sum equal to about 30 percent of the present plant investment. To remove 100 percent at this time would be impractical. However, the present methods of renovation do not bring any return on the investment except, of course, in the satisfaction of having alleviated stream pollution. Therefore, any treatment procedure which would include processes rendering a return would ease and distribute the costs. Such return could mean the difference between failure and continued business for a marginal company.

As many of you know, the amino acompounds of potatoes are principally divided between free amino acids and proteins. Almost 100 percent of these compounds end up in the secondary portion of the plant waste effluent. The proteins are known to be one of the nutritionally better plant proteins. The free amino acids are also a pretty well balanced substitute for protein and, in addition, may be important as starting materials for other uses which we will discuss later. Several years ago the Eastern Division developed a laboratory scale ion exchange system for recovery of the free amino acids from protein water. At about that time we were required to work on other projects and no more experimental work was done. Since that time, developments in ion exchange technology have increased the chances for success of the procedure and, as a result of need of the starch industry, permission to work on waste treatment was obtained. These developments are two-fold: (1) the use of back-flow instead of down-flow operation to take care of solutions carrying fine, insoluble materials, and (2) the improvement of engineering design so that full industrial-scale equipment can be designed and constructed from data obtained with one-inch-diameter columns in the laboratory. This micro-scale system eliminates the necessity for the much more expensive pilot plant studies formerly required.

Promising work in Europe has been reported to show that it may be possible to economically precipitate the proteins from protein water in a form that can be handled with ordinary

filtering and drying equipment. Since the nitrogen compounds in the waste water are about equally divided between soluble proteins and free amino acids, recovery of the proteins would double the possibility of obtaining valuable compounds over just the amino acids. Since the proteins must be removed before ion exchange treatment of the waste effluent, the added cost of recovery would be negligible.

Our ion exchange studies of the organic acids in potatoes lead us to think that a good possibility exists for removal of these materials in conjunction with the above recoveries. A relatively high content of citric acid could well make it pay. An added advantage would be removal of inorganic and organic phosphates which will make the final effluent media less favorable for algae production in lagoon operations.

Finally, one of the techniques being studied nationally, to produce potable water from salt or brackish water, is reverse osmosis. If a solution containing salt is separated from pure water by a membrane having a pore size smaller than hydrated ions in solution but larger than a molecule of water, in other words a semi-permeable membrane, water will pass into the salt solution from the pure solvent side and create a pressure. This has been named "osmotic pressure." It was discovered that application of a pressure greater than this osmotic pressure, on the salt side of the membrane will cause water to pass through the membrane and concentrate the salt. This can be continued until the increased salt concentration produces an osmotic pressure so high as to be impractical. In other words this is "reverse osmosis." In this manner, potable water can be obtained at the cost of the electrical energy required to run the pump to produce the pressure plus membrane replacement, capital equipment, labor, etc. This means that 100,000 gallons of a 1-percent salt (or potato solids) solution when concentrated by reverse osmosis to 50,000 gallons of a 2-percent solution would, at the same time, produce 50,000 gallons of pure water for immediate reuse. We have demonstrated in our laboratory the possibility of concentration of a 1-percent protein water to 10-percent solids. For obvious reasons, the more concentrated influent would be more advantageous in a plant producing valuable compounds. It probably will not be necessary or economical to concentrate beyond 1.5 to possibly 5 percent.

After removal of the proteins, amino acids and organic acids, all of which require oxygen for biological treatment, the influent to the lagoons would contain mostly sugars and the BOD would be lowered to about 20 to 25 percent of that of the original secondary plant effluent. Since sugars are relatively easy to decompose biologically, the removal of the final BOD of the plant effluent should be improved.

It is, therefore, our purpose to develop an integrated system in the laboratory involving these techniques, namely reverse osmosis, protein precipitation, amino acid recovery, and organic acid recovery. When this system is in working operation, we plan to build a demonstration unit, capable of producing about 25 pounds each of proteins and amino acids and 30 pounds of organic acids per day. This unit will be set up in a starch factory and operated for sufficient time to discover any difficulties in operation, determine the economics of the integrated process, and produce a supply of these materials for use in studies of their possible end uses.

Studies of end uses will involve determination of specific nutritive values of the proteins and amino acids, studies on production of flavor extenders and users as starting materials for new products, etc. In addition, studies will be carried out in possible production of pure preparations of certain individual amino acids and organic acids.

It must be remembered that this is a report on planned work, started last February, and to continue at least until December, 1970. It must also be remembered that much work was completed some years ago, the results of which are the basis of the studies just discussed. Only intensive studies can tell us whether the processes can be made to work on an industrial scale and whether they can be made sufficiently economical to take their place as an integrated part of the potato starch processing industry. I do not want to leave you with the impression that the problem of waste disposal has been solved and that all we have to do is carry out the laboratory experiments. The ion exchange techniques have been proved possible, the protein recovery system has been used in Europe, reverse osmosis has been employed in pilot plant treatments of salt water and of sewage effluents. However, when you translate these experiences from pilot plant studies on a maximum of several thousand gallons a day to an estimated 290,000 gallons per day, then size of plant, economics, and the multitude of problems which may develop must be considered. It is our view that the work must be done now because there is no way of predicting whether the idea is economically feasible without the information and experience.

CONTRACTING OF POTATOES -- A PROCESSOR'S VIEWPOINT

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Several methods for acquiring potatoes are available to the processor. Basically these fall into three categories: grow, open market purchases, and contract. In the "grow" category the processor becomes his own source of supply to the extent that he grows potatoes for his own use. He becomes a competitor to the farmer who supplies the remainder of his requirements. In addition, he is faced with rotation crops and their disposition and he is entering a very specialized area.

The investment to enter the field of farming is considerable and at this point the processor must calculate his return to determine where his capital can be utilized to the best advantage. Should he invest in plant facilities or in farming? The farm community is stable. It has vast knowledge. It has been improving steadily and rapidly. For this reason it is our contention that farming should remain with the farmer and that processing should remain with the processor.

Another method of procuring potatoes is the open-market purchase. This plan is relatively simple but has grave implications. It usually works thus. The processor needs raw material and he contacts a grower and/or shipper to obtain his potatoes at the current market price, or at some agreed upon future price if he is buying for future delivery. The complications of this system are many: (a) Potatoes stored for the table stock market are generally not suitable for processing. (b) It is a wide-open gamble as to what the market price will be when the potatoes are needed. (c) The availability of the potatoes is not predictable.

To amplify briefly, potatoes stored at 38°F. or lower for table stock cannot be considered prime processing stock. Much has been written and spoken about sugars and starches and the conversions connected therewith, with the consensus being generally that temperatures below 42°F. are not acceptable for processing stock.

To try to operate strictly on cash purchases would lend nothing but chaos to the pricing structure of both grower and processor. Neither would know from one moment to the next what he could expect as a return for his efforts. Hence, basic economics would rule out cash purchases as the prime source of raw material.

Lastly, availability of the correct type, solids, size, sugars, as well as quality, is important. A tight fresh market could shorten available supplies and in turn affect the processor's position if he is unable to supply the quality specified by his customers.

To turn to the positive position, let us now explore the contracting of potatoes, which is our subject. I believe all processors contract to some extent. It is Lamb-Weston's contention that the greater the extent the better for all--grower, processor, and consumer. The first avenue to explore is cost. When a processor contracts a high percentage of his requirements, he is establishing his raw material costs at a predetermined level. He knows that under varying sets of conditions he will be able to produce for a known amount and not have to speculate for months in advance.

The grower who contracts a large percentage of his crop can make long-range plans for his ground and equipment requirements and can pattern his growth on a sound rather than a speculative foundation. He won't "strike it as rich" in the high years; he won't "go as broke" in the low years, but he will receive a fair return for his crop. It is our observation that over the years our contract farmers average the best net returns on their crop and remain in the best financial condition. The price risk for the grower is taken out of the portion of his crop that he contracts. I have never known a processor who has not honored the terms of his contract and if he is reputable and intends to stay in business, I doubt that it ever will happen.

A grower who has a contract has an incentive to produce a better crop and to handle it in a better manner. Most processors pay premiums for size. Some pay premiums for better handling techniques and proper storage conditions. These specifications also help the processor, but we have a mutual interest with the grower and that is to get the public to consume more potatoes. To do this we must give them a top-quality product at a price competitive with other starch foods.

While on the subject of contract conditions, I feel it most proper that conditions related to plant production should be included in the contract. For example, better handling to reduce bruising can be more economically implemented in the field and storage than it can be corrected in the plant. Size, solids, and type can be largely controlled and improved by the grower, and these factors should be included in contracts. Likewise sugars and other storage-related factors are desirable contractual elements for which the processor should be willing to affix a premium and the grower to accept a penalty.

Quality is our watchword. Where does quality start? Obviously not at the potato receiving room. Quality started when the grower selected his seed potatoes and then inched along somewhat in the following manner. What field will I plant it in? What will be the irrigation pattern? What are the programs for fertilizer and disease and insect control? Defoliating will be carried out at what time and how? Harvesting--a main category of its own--is all important to quality as is storage. Considering these points it becomes quite obvious that to obtain the best raw material it is necessary to select good growers, know what fields are best, watch over your contracted crops as they grow, are harvested, and are stored. You cannot do this and buy all of your potatoes on the open market.

Being able to provide your customers with a continuing supply of product of consistently good quality is one of the prime marketing considerations. This, like the other aspects mentioned, can be controlled to a great degree with good raw material and availability of it. The components of good raw material are high solids, low and uniform sugars, good type, lack of bruising and damage, no rot, disease, insect damage, etc. The best way to insure all of these in their respective degrees of occurrence is to select good growers, good fields, follow good growing practices, and harvest and store correctly. Obviously this can best be accomplished by contracting with the aforementioned factors in mind.

We all seem to have a touch of gambler in our makeup, whether it is going over the speed limit, standing at the tables in Las Vegas, or speculating on what the potato market will be for the coming year. As we all know, the potato market is a commodity market and commodity markets are very volatile. Contracting of potatoes, in our estimation, is one of the best methods of counteracting the volatile aspects of the market. The processor knows what his plant costs will be for the year at time of harvest, but if he has not contracted, his costs and market stability are unpredictable and his degree of gamble is increased.

From a competitive position market stability is much desired. When the processor finds his competition buying low-cost, poor-quality raw material and producing French fries, he finds the whole finished product market deteriorating. If all producers of potato products would contract at prices fair and equitable to the grower and at levels of their total usage sufficient to lend stability to the market, the current speculators would soon be doing the same in order to provide their customers with a high-quality dependable source of supply.

We feel that for processors to contract a high percentage of their requirements is good for grower, processor and consumer in providing a stable market and high-quality product.

THE ECONOMIC IMPLICATIONS OF GROWER-PROCESSOR CONTRACTING IN THE POTATO INDUSTRY

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What is contracting? To what extent has contracting contributed to or detracted from the development of the potato industry? Has contracting had an adverse or a beneficial effect on the quality of potatoes produced? What is the relationship between contracting and the currently popular topic of "farmer bargaining power?" These are the types of questions which I shall discuss.

The term "contracting" does not describe a single, well-defined practice. Rather, contracting can refer to a number of different arrangements with a wide variation in the conditions specified, including the functions to be performed, the risks to be borne, and the compensation to be received by each party. Even within the potato industry different types of contracting can be observed. For example, contracts can be negotiated through a formal futures market such as the New York Commodity Exchange or the Chicago Board of Trade. Or, contracts can be negotiated directly by the parties involved. Differences may also exist in the latter type of contracts, depending on the nature and location of the firms involved. For example, grower-shipper contracts may be different from grower-processor contracts, which may in turn depend on whether the processor is a chipper or a dehydrator-freezer and whether the growers are located in Maine, the Red River Valley, or Idaho.

This paper focuses attention on contracts commonly used by growers and processors in Idaho. Casual observation indicates that these arrangements resemble those used by at least some other firms in other areas.

Basically, the contracts are documents whereby the grower agrees to furnish the production from a given acreage to a processor, who in turn agrees to pay a specified base price per hundredweight. The base price is usually adjusted to a limited extent at delivery according to quality and/or size of the potatoes and may be further adjusted to cover storage costs if the potatoes are stored by the grower. Most contracts are negotiated prior to or at time of planting, although some may be negotiated between planting and harvest. Control of the potatoes with respect to time of movement into the marketing channel and use to which they are put rests with the processor.

Contracting vs. price uncertainty.--Perhaps the most significant aspect of these contracts is that price per hundredweight is specified as an integral part of the contract. Furthermore, the fact that the price is negotiated prior to planting means that most growers know, within fairly narrow limits, the price they will receive before they make their final production decisions. This is in contrast to the contractual arrangements for a number of other commodities where price is either not specified or is determined according to a specified formula after the contract is negotiated.

The contention that the specified price is the most significant aspect is based on the fact that potatoes have, historically, been subject to a high degree of price uncertainty. Prices can increase by more than 100 percent or decrease by more than 50 percent from one year to another (see table 1).

Table 1.--Idaho potato prices, 1950-66
(Statistical Reporting Service, USDA)

Year	Season average price ($/cwt.)	Current price as a percentage of previous year
	$	%
1950	.85	
1951	2.25	265
1952	2.50	111
1953	.96	38
1954	1.89	197
1955	1.39	74
1956	1.18	85
1957	1.52	129
1958	1.00	66
1959	2.09	209
1960	1.83	88
1961	1.05	57
1962	1.48	141
1963	1.55	105
1964	3.24	209
1965	1.93	60
1966	1.67	87

The effect of price uncertainty becomes apparent when one recalls that potato production requires a substantial investment in land, equipment, and facilities as well as high out-of-pocket expenses for seed, fertilizer, irrigation, equipment operation, and labor. Growers can be expected to limit the scale of their operation to avoid losing everything in one bad price year or diversify their operation to include crops with less

price uncertainty. Lenders can be expected to be cautious about putting money into an industry subject to wide price variations.

Conversely, the reduction of price uncertainty associated with contracts can be expected to have an opposite effect. Obviously, lenders can be expected to feel more justified in providing short-term credit when loans are secured by contract. Availability of contracts can be expected to make long-term investments in land and irrigation facilities more secure. Even more important, however, is the fact that growers can be less hesitant to invest the level of resources required to achieve efficient operation and adopt new techniques when risk is reduced.

An examination of potato production in the State over a period in which contracts have been in use lends some support to these arguments. Estimates of the acreage and production of potatoes in Idaho since 1950 are shown in table 2. Total acreage

Table 2.--Idaho potatoes: acreage and production, 1950-67 (Statistical Reporting Service, USDA)

Year	Acreage (1,000 acres)	Production (1,000 cwt.)
1950	165.0	30,516
1951	133.0	23,055
1952	140.6	26,929
1953	166.0	30,690
1954	155.9	26,608
1955	175.7	33,188
1956	182.8	33,730
1957	187.1	39,018
1958	214.4	45,568
1959	212.0	42,408
1960	238.1	43,078
1961	287.0	57,734
1962	253.3	44,919
1963	242.5	53,466
1964	247.1	39,698
1965	283.0	61,695
1966	311.8	70,190
1967	304.0	63,900

has increased from an average of 146,000 per year during the period 1950-52 to nearly 300,000 acres per year for 1965-67. Total production has increased over the same period from an average of about 27 million hundredweights per year in 1950-52 to over 65 million for 1965-67. The number of farms producing potatoes in the State has decreased from over 12,000 according to the 1950 Census to fewer than 4,500 in 1964. Average

acreage per farm has increased from about 12 acres in 1950 to over 50 according to the 1964 Census. While Census probably includes "non-commercial" growers and hence understates the size of the typical producing unit, it provides some idea of the rate at which units have grown.

Citing these figures should not be construed as implying that contracts have caused the expansion of potato production nor the adjustment of individual potato farms to larger, more efficient units. This would be like saying that the availability of roads caused the invention of the automobile. Such an adjustment would have been extremely difficult if not impossible, however, under the conditions of price uncertainty which have historically existed in the potato industry. Contracting has provided one means for reducing this level of uncertainty and, therefore, has contributed, along with other factors, toward expansion and adjustment of the industry.

The fact should also be noted that expansion and adjustment have not been an unmixed blessing. I am sure many growers in other sections would contend that Idaho producers have overexpanded during a number of recent years. Even within Idaho many smaller or less efficient operations have been squeezed out because they were not able to adjust to larger scales or more efficient techniques. Consequently, to the extent that contracting has contributed to expansion of production and development of large-scale units, it must also share in the blame for displacement of resources formerly employed in the potato industry. Thus, while we tend to look with favor on increased efficiency, we should recognize that all members of the industry have not shared in the benefits and some have actually suffered.

My remarks to this point have centered on the contention that contracting has contributed to the expansion of the industry in Idaho and to the adjustment process of producing units. I would like now to consider other implications. In these cases there is less evidence and so my remarks are offered largely as questions which need answers and as observations based on my own experience.

Contracting and quality.--Consider first the effect of contracting on quality of the potato crop. Conflicting views have been expressed within the industry concerning this aspect of contracting. On the one side are those who contend that contracting has focused attention on maximum tonnage at minimum cost and that quality has therefore declined. On the other side are those who point to the fact that most contracts contain provisions for incentive payments for higher quality. Moreover, they can point to the fact that contractors receive the benefit of technical

assistance from processor fieldmen, which should enable them to produce a higher-quality crop.

My own observations are, first, that there have been growers who, because of size or inexperience, have been unable to perform all the functions required for high-quality crops. To some extent, at least, some may have been enticed in this direction by the existence of contracts with specified prices. On the other hand, I am told by my plant scientist friends that there are few if any practices which increase tonnage per acre and also decrease quality. Moreover, there are few if any practices that a small grower performs which cannot also be performed in a large, efficient operation if managed properly. My own conclusion is, therefore, that while some potatoes grown under contracts in the past left something to be desired in quality, there is no inherent reason for this to persist as a chronic condition. However, I would like to see some additional study of this question.

Contracting and farmer bargaining power.--Another set of questions is related to the whole area of farmer bargaining power. Needless to say, questions along these lines transcend grower-processor contracting of potatoes, since they apply to numerous cases throughout all of agriculture. However, the conditions encountered in the negotiation of potato contracts appear, on the surface at least to typify conditions in the more general case in which a number of small sellers must bargain with one or a few large buyers.

Raising questions along these lines should in no way be construed as an indictment of any firm or group of firms. In fact, there is a notable lack of agreement even among economists concerning implications of this type of market structure in a dynamic setting. While most economists agree that monopoly power (or in this case monopsony power) in the classical sense is something to be avoided, no one seems quite sure of the extent to which modern industries with their strong emphasis on technological change fall within the classical framework. As a consequence, economists are left without a well-defined measure of performance by which to judge such industries.

Nevertheless, questions are being raised concerning the extent to which farmers may be deprived of benefits accruing to other segments of the economy as a result of their peculiar bargaining position. Further questions are being raised with respect to possible approaches to improved farmer bargaining power.

Certainly questions related to the nature of competition and farmers' bargaining position have been raised within the Idaho industry in the context of negotiating contract prices. Group actions on the part of farmers have also been instituted to improve grower bargaining power. Perhaps only time will tell whether or not the need actually exists for such actions and whether or not they can be effective if needed. To the extent that they are successful in these actions growers may have more bargaining power in negotiating prices than they had before the advent of contracting.

Furthermore, it is easy to underestimate the degree of competition which actually prevails within the industry. In addition to the competition between individual processors for supplies it must be remembered that fresh dealers are still active in Idaho. Some also engage in a certain amount of contracting and, of course, there is always the alternative of holding for open market sales. More recently, the institution of a formal Idaho potato futures contract adds another competitive dimension to the industry.

Having said all this I would still contend that, in light of the current intense interest in farmer's bargaining power, questions will continue with respect to the contracting of potatoes and efforts will continue to modify the bargaining process through which price is determined. A good deal of judgment and cooperation will be needed on the part of industry leaders and those who work with the industry in the various government services and universities to channel these efforts along constructive lines and avoid unwarranted conflict and antagonism between segments of the industry.

In conclusion I would like to reiterate that contracting has aided the expansion and adjustment process of individual firms and, hence, contributed toward improved efficiency of the Idaho industry. While questions have been raised and problems noted with respect to quality and conditions of imperfect competition, these problems cannot be attributed directly to contracting. In fact contracting may have contributed as much toward alleviating these problems as it has to the causes. On this basis I would conclude that contracting will remain as a permanent and largely beneficial dimension of the Idaho potato industry in the years ahead.

A REVIEW OF CURRENT DEEP FRYING PRACTICES POINTS THE WAY TO NEW HORIZONS [1/]

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Deep fat frying is a method of cooking a distinctive food, one for which there is a healthy public appetite. So great is this appetite that an educated guestimate based upon figures obtained from industry, publications, trade associations, and government would conservatively place the present deep-fried food market at $2.75 billion, involving over 1 billion pounds of frying fat, most of which is consumed in the fried foods. Only a small amount is thrown away as "spent" fat.

The home kitchen produces only a minor quantity of deep-fried foods and for various good reasons, not the least of which is the inability of the housewife to turn out consistently good products. So deep-fat frying is one form of food preparation over which the commercial processor presides as king and ruler, be he a food service or an industrial processor. The subject belongs then squarely within the area of concern of the professional food technologist.

A list of commercially deep-fried foods would include potato and corn chips; doughnuts and crullers of all types; frozen French fried potatoes and other potato products; frozen fried seafood products such as fish sticks and fillets, scallops, shrimp, crab and fishcakes; frozen fried blintzes; Chinese noodles; canned and frozen fried onion rings; and items fried and served in restaurants. Potato products constitute by far the major single area of the frying world.

My purpose is to review the current deep-frying practices by describing (1) the process and (2) the nature of the finished product, pointing out the "why" of its distinctiveness; and (3) to point out the avenues which can be and are being taken to improve both process and product.

Deep fat frying.--Deep fat frying is the process whereby the properly prepared food is cooked or "fried" in a body of edible fat or oil, hereinafter referred to as the "frying fat." Fed to the reaction chamber, or "kettle" as it is called are: the prepared

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1/ Based upon a paper presented at the Canadian Institute of Food Technology Meeting at Montreal, Canada, on May 25, 1967, and published in July 1968, by the Canadian Institute of Food Technology Journal.

raw food, the frying fat, and heat (BTU's). These, we can see, are the input factors. For the output factors we list: steam, steam-entrained fat and fatty by-products (and other steam-volatile products and/or by-products issuing from the raw food in frying), the finished fried food, and the filtered crumbs.

First it goes without saying that it is not possible in the frying process to upgrade food of low or mediocre quality to a high-quality product. The reverse, however, can be true. Therefore, high-quality raw food is what you must start with. Short cuts or mistakes in the preparation of this food for frying can result in damage both to the fat and to the product out of proportion to the time and effort required for doing the job right.

The pieces to be fried should be: (1) as uniform in size as possible, (2) as free as possible from any excess crumbs, fragments or surface water, (3) at the proper temperature required to yield best results, (4) if breaded, not only must the properly designed breading material to yield proper color for its frying time and temperature be used, but this breading must be applied firmly so that only the minimum amount becomes dislodged, (5) the prepared food, whether breaded or not, should contain surface-wise, at least, the <u>minimum</u> amount of chemicals such as salt, sodium bisulfite, or ammonium carbonate, or contamination with copper salts, which can have a damaging effect upon the hot frying fat, or binding materials on the surface such as starch which can cause the unfried pieces to stick together in frying and, (6) potatoes especially must be properly conditioned to yield the optimum color.

The frying temperatures required range from 325°F. to 380°F., depending mainly upon the nature of the food. For example, frozen chicken pieces, especially thighs, may call for only 325°F. A higher temperature might result in an overcooked surface before the interior is done, while doughnuts require about 380°F. Most commercial frying, however, is carried out in the range of 350°F. to 365°F.

The amount of heat or BTU's required is minimal, even though the raw food may be frozen. By far the greatest number of BTU's consumed in frying is to generate the steam from the food being fried and to compensate for its cooling effect upon the hot frying fat as the steam is driven off. Application of this heat is of utmost importance, but because it is so intimately related to the design of the kettle used for frying, discussion on this aspect will be resumed under the heading "kettle design."

The <u>frying fat</u> is the focal point. It should be carefully selected first to conform to the needs of the product. In general,

better eating and appearance will go along with use of the lower melting fat. Most consumers are definitely vegetable oriented with increasing interest in the polyunsaturated aspect. The fat should be bland and neutral in flavor and odor. If it has been processed with added flavor designed to enhance product appeal, then of course it becomes a question whether or not your customers like it.

The frying fat must have maximum stability. It should offer the ultimate in ease and foolproofness of handling. In this regard, a liquid fat is best. The industrial operator, if he does not use a fat that is already liquid at room temperature, can handle his solid fat in tanks where it is kept liquid by storing it above its melting point. The restaurant operator, where tank handling for him of course is unfeasible, has fats available that are liquid at room temperature, fats that exhibit even greater kettle stability than do most solid fats.

Almost as soon as the frying fat is put into the kettle it begins to undergo a process of attrition which, if not inhibited or checked by proper maintenance, will soon spell "finis" to its frying life. These factors are the effects of: (1) heating in the presence of air (including unnecessary aeration), (2) temperature at point of contact with heat source, (3) contact with food substances being fried, (4) contact with loose crumbs or particles which can burn and release flavor-damaging gases and other volatile by-products and impart a scorched flavor to the fat, and (5) contact with metal in equipment. Of these factors, the effect of heating in the presence of air seems to be the most damaging, for heating alone with no frying will eventually cause a frying fat to "foam" when later put into service, thus rendering its use impracticable.

Most of these other factors, like heat application, will be discussed later on. In the case of contact with food substances being fried (point 3 above), the steam generated in contact with the hot fat encourages fat hydrolysis, resulting in modest increases in free fatty acid content, not at all damaging unless the fatty acids are of low molecular weight such as are derived from a cocount-oil type of fat, whereupon the fat and finished product will acquire a "soapy" flavor. In the frying of doughnuts, it has been reported that a certain percentage of free fatty acid must first be induced in the fat before the doughnuts can be optimum in shape. Contact with certain metal salts, particularly copper, which may be present in or on the surface of the food can either directly or indirectly catalyze degradation of the fat and contribute to its premature demise.

Those factors of maintenance which militate against the process of fat degradation are: (1) escaping steam, (2) filtration to remove crumbs and fragments, (3) addition of fresh fat to replace the fat removed from the kettle in frying, (4) observance of factors contributing to short turnover period, and (5) proper cleaning of equipment. The escaping steam, though it does contribute to fat hydrolysis, performs the useful function of washing, scrubbing, or purging the fat of much of the volatile by-products of the heating and frying process, which would otherwise render it unfit from the standpoints of odor and flavor. Thus, the escaping steam acts as a sort of low-grade steam deodorization process. The problem of eliminating crumbs and fragments is accomplished usually by filtration, either batchwise or continuous. The fresh fat added to the kettle to compensate for fat removed in the finished food helps overcome the loss of performance brought about by heat and other factors. This ratio of the total amount of fat in the kettle system to the rate at which fresh fat is added is referred to as "turnover period." Naturally, the shorter the turnover period, the better the condition of the fat in the kettle. The "turnover period" reveals to us certain other principles of fat maintenance, the proper observance of which will benefit the condition of the frying fat in use, such as: (1) do not overfill the kettle, (2) do not hold fat at frying temperature longer than absolutely necessary when not frying, (3) keep production rate at maximum, (4) fry for fewer long intervals, rather than for many short ones, (5) make sure optimum fat absorption is being maintained.

In industrial frying operations (doughnuts, chips, frozen French fried potatoes, seafoods, etc.) where frying is continuous and good kettle design and practices are routine, this turnover period is short enough that an equilibrium point is reached in the frying fat between the effect of the attrition factors and the proper maintenance factors. At this equilibrium point fat remains in such good condition that it stays "alive" indefinitely and is seldom if ever discarded. Turnover periods of 12 hours or less are not uncommon in industry. In restaurant frying, however, because of too much idle kettle heating time, there usually comes a time when fat must be discarded.

Factors that affect proper kettle design.--Factors in kettle design that can help minimize the deterioration of the condition of the frying fat in the kettles are: (1) minimum of frying fat capacity in kettle system, (2) maximum production capacity, (3) minimum temperatures at heating surface, (4) adequate temperature control, (5) proper material of fabrication, (6) maximum ease of cleaning, (7) minimum amount of aeration, (8) provision for efficient and complete removal of steam and steam volatile products and by-products.

The amount of fat in the frying system should be the minimum required. There should be no "quiet corners" or excess depths that are not concerned with frying, exchanging of heat, or filtering. The system rather than the kettle itself is specified because there are frying operations with external heat exchangers and perhaps with built-in filtering devices which require a certain volume of fat at or near frying temperature at all times for normal functioning. To have more fat in the frying system than is needed is to be "burning up" tomorrow's fat today. The second factor, maximum production capacity, deserves special mention lest a frying system be designed which is incapable of delivering adequate heat for a sustained operation.

It is a matter of simple arithmetic to figure out the minimum BTU requirements for a frying operation from the composition, temperature and weight of the food going into the kettle and those of the finished food. Potato chips may require 350,000 BTU's per hour for a production rate of 100 pounds of finished chips per hour, while French-fried potatoes may ask for only about one fourth as many. This difference is usually at least partially compensated by a greater rate of production through the same system where the BTU requirement per unit volume of food is less.

The manner in which the heat is distributed to the fat is very important. The heat required for frying must be distributed as evenly as possible over a relatively large area or surface, the larger the better. Today it is accomplished by forcing the heat (usually gas) through tubes immersed in the body of the frying fat, either horizontal to the flow of the food or in direct line therewith. In small batch kettles, heat is supplied either by gas or electricity. In the latter case heat is furnished by a network or system of heating coils. In more recent years the principle of heating the fat externally and pumping it to the kettle as needed has been utilized. There are at least three variations, one using high pressure steam, another hot air, and a third, other heat exchange media. The main advantages of external heat exchange are: (1) It can, if properly applied, reduce the heating surface temperature required to pass the needed heat to the fat. (2) It makes possible the reduction of the amount of fat needed in the kettle to accomplish the frying. Over and above these benefits, however, must be considered the disadvantage of the extra amount of fat added to the system to make it possible for this heat exchanging unit to function.

Proper temperature control is a "must" in any well designed frying kettle. This means not only that the proper thermostatic equipment must be furnished, but also that the location of the "take-off" bulbs actuating the thermostats must

give a faithful picture of the actual frying temperature. There is much to be said for a "self-modulating" system of temperature control where the heat fluctuates gradually according to requirement, rather than by a complete shutting off with subsequent full blast heat application.

Work of years' standing has described the effect on quality of an edible fat of various materials of fabrication. Glass is known to be relatively inert in its effect. In a system which must be washed frequently with detergent, aluminum becomes impracticable. Price rules out nickel, but stainless steel, though expensive, seems to be the most practical. There is some risk in using black iron or mild steel. Certainly any copper or copper-bearing metals anywhere in the system must be avoided, because copper has a highly pro-oxidative effect upon fat. Even one brass valve or bronze pump part in the system can be the source of trouble, not only in the fat, but also in the finished product.

Periodically for the good of the fat and the product the kettle system must be cleaned to free it of burned-on bits and crumbs by scrubbing, scraping, detergent washing or by any combination thereof. In the course of frying, bits of food and crumbs become dispersed in the fat where they may contribute defects to finished products as well as fat problems. Particularly is this true with foods that have been breaded. It is the burden of the kettle designer to provide the best conditions for removal of this waste material. This problem is dealt with in a number of ways, from providing a cold zone beneath the heating tubes where hopefully the crumbs will not burn to circulating the fat to a filter. Where external heat exchangers are employed the equipment designer should provide adequate filtration before the fat is circulated to the heat exchanger, lest these crumbs marinate in the fat or burn further, or plug up the line to, in, or from the heat exchanger, in which case fires have been known to develop.

The <u>effect of air on the hot fat</u> is perhaps the major factor affecting fat in the system. Contact with air on the surface of the fat and with air dissolved in the fat is unavoidable. Any additional aeration such as cascading or spraying of hot fat anywhere in the system, all of which is really unnecessary, must be eliminated, and also, use of pumps that suck in or churn in air.

Because the steam given off in frying helps in purging the fat of volatile by-products, it is important not only that adequate exhaust be provided but also that this system be so baffled as to prevent drip back of condensate into the kettle. Too great a draft

must be guarded against lest it cool the kettle fat too much and result in problems.

<u>The finished fried food defined and described</u>.--For a proper understanding of deep-fried foods let us now consider their anatomy. All fried foods have the same basic structure, which is imposed on them by the manner in which they are cooked. The <u>outer zone surface</u>, which strikes the eye of the consumer, has an even, golden brown color and transmits the message that the food is "done" just right. This color is not the result of an accident. It has been brought about by the effect of the kettle heat on the composition and the sugar-protein balance of the outer part. It is the result of a chemical reaction known as the browning or Maillard reaction. Color development depends upon the time and temperature of frying, in combination with the composition of the food. The type of fat used has very little to do with color unless it has been especially treated to enhance fried food color. Accompanying this color is a nuance of flavor which is as typical of deep-fried food as a smoky flavor is of barbecued foods, or a toasted flavor is of toast.

The outer zone itself is a crisp crust, produced by dehydration of the outer portion. The hot fat has driven the water from this outer portion, accounting for most of the steam released. As the water was removed, some of the fat partially replaced the void created by the loss of water. Each type of fried food seems to have its normal amount of absorbed fat, depending roughly on the ratio of crust to core. For example, potato chips may contain 40 percent of absorbed fat; potato sticks 35, doughnuts, 20 to 25; fried shrimp and scallops, 12 to 15; fish sticks, 10 to 12; and French fried potatoes, 7 to 10 percent. The type of fat used seems to have little to do with amount absorbed, for this is a function of viscosity of the fat at the frying temperature, and in this respect all fats normally used are about equal.

This absorbed fat performs at least two useful functions. It has a tenderizing effect upon the crust in much the same fashion that shortening tenderizes a pie crust or a cookie, and the absorbed fat has a "wetting" effect which enhances eating quality in much the same fashion that butter or margarine affects a piece of toast. The inner zone is a cooked, moist core. Fried foods are never finer than when they come fresh from the kettle, because as they stand, warm or cool, the moisture in the inner zone migrates into the outer zone and destroys crispness. Those who manufacture potato chips, corn chips, and other core-less products must guard against loss of consumer appeal by moisture-proof packaging to withstand invasion of moisture from the outside. The conscientious restaurant operator, however, must guard against

invasion of moisture from within the food, by rapid service to the customer. And if the housewife would restore crispness to various frozen prepared fried foods without refrying as most restaurants and institutions do, but just by heating, the future of this food business could perhaps be unlimited.

The way to new horizons for deep-fried foods.--The present healthy public appetite for deep-fried foods has not always been so healthy. Progress has been due in great measure to improvements in equipment, frying techniques, and fats, sparked by a growing awareness of the problems involved. Also, the notion that deep-fried foods are somehow not the best nutritionally has suddenly become old fashioned. It could be that improvements over this period have had much to do with this change in attitude. While retail sales of deep-fried items continue to climb, particularly in restaurant and snack frying (the Potato Chip Institute reports growth of about 9 percent a year), the real impetus for growth must come from further improvements in the products. Substantial growth must pay for these improvements.

The first approach to better techniques is to strengthen their weaknesses, and the most obvious weakness is the effect of air on the hot fat. The simplest way to minimize this problem is to turn off the heat when the kettles are not frying or turn kettles down to idling temperatures of say 200°F., and in industrial frying, to be sure that product is being fried to capacity when the kettle heat is on.

In recent years, the practice of treating frying fats with very low quantities of methyl silicone has been patented and introduced. In theory the methyl silicone orients itself in a monomolecular film on the surface and slows down the process of heat degradation. It has been demonstrated that a tight-fitting cover over the frying fat practically stops heat attrition, but it may be difficult to fry with such a cover in place. Perhaps some means of utilizing an inert atmosphere over the kettle can be applied to reduce this attrition.

Work has only been started on use of the principle of heating of frying fats at as low a surface temperature as possible using foolproof and effective heat exchange media such as high pressure steam, without substantially increasing kettle system capacity, or even decreasing total frying fat capacity. Another development which will be published shortly called "integral heating" utilizes the principle of low-wattage electric heat spread evenly over the bottom or lower side of the kettle, a method which will afford heat distribution over as wide an area as possible with the lowest possible surface temperature. Accompanying this will be a glazing of the inside of the kettle

with a special "indestructible" ceramic material which will also offer a more inert surface to the fat. This development can be useful for heating the kettle both directly and indirectly as through a heat exchanger.

Microwave heat can be used to supplement conventional heat sources where its effect of inside cooking will quickly take care of the heat requirements of the inner zone, thus reducing frying time, increasing production rate, and decreasing turnover period. This application can be used either in conjunction with the kettle or in tandem. Considerable work has already been done on its application to the potato chips, in tandem. Much work in this field has been done and reported by Dr. Ora Smith, and several industrial installations utilizing this form of heat have already been in production. The idea here is to fry the chips in the conventionally heated kettle to a moisture content of 6 to 7 percent instead of the usual 1 to 2 percent, and to complete the process in a microwave-heated tunnel. In addition to improving turnover in the kettle, this method offers great flexibility in chip color control.

Effective ways will be found to continuously filter a frying fat and keep it at all times essentially free of crumbs and fragments. The fat which is filtered will perhaps be cooled during or just after filtering and heated again just before entering the kettle, utilizing the same heat taken out in the cooling process for reheating. Since it is already known that much of the filtration problem can be eliminated by not allowing the crumbs to enter the kettle, more adequate equipment must be provided to combat this. Perhaps a foolproof, effectively ventilated portable kettle, can be developed that can be wheeled tableside in a restaurant to cook and serve fried foods to order.

SPECIAL PROBLEMS OF THE POTATO CHIP INDUSTRY IN WESTERN EUROPE

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There is no country in Western Europe with a per capita consumption of potato chips equal to that of the USA. Annual consumption in grams in a few countries is estimated as follows:

United Kingdom	1500 grams	Sweden	250 grams
Netherlands	650	Norway	450
Western Germany	100	Switzerland	400
Denmark	250	France	250

There are several reasons why consumption in your country is so much larger than ours in Western Europe. A most important reason is certainly the large difference in quality, and the difference in quality is for the most part due to the raw material the Western European chippers have at their disposal.

We have many nationalities in Western Europe, and as a result we have a large number of potato varieties. Almost every country has its own recommended list. These lists includes approximately 700 varieties. Of course many are listed twice or more times. The total number of different varieties is probably closer to 300. Until about 10 years ago little was known about the suitability of these varieties for chip processing. The United Kingdom, the only country in which industrial chip processing had attained some significance, mostly uses the Record variety, which produces chips of a fairly good quality.

Professor Ora Smith of Cornell, who maintains contacts with all members of the Potato Chip Institute, including those in Western Europe, proved helpful in 1960, and again even more in 1962, when he advised our chippers to contribute to the research on the suitability of the West European potato varieties for chip processing, which had been started in Wageningen in 1957. Also as a result of this advice our chip industry has established co-operation with agricultural research in Europe. A large number of potato varieties have been tested and some suitable varieties have come forward from this research. The principal requirement for a good variety is that it should give chips of a light colour. That is, the variety should have a low reducing sugar content.

National research on varieties.--The problems, however, have not been solved. A variety suitable for the chip industry cannot be grown in just any West European country. This is contrary

to legislation in the different countries. A variety must be tested extensively in those countries where it does not appear on the recommended list. This usually demands years.

National consumption usages.--The requirements for potato varieties vary from country to country, depending on consumption usages. In the United Kingdom and Portugal white-fleshed potatoes are preferred while in all other countries the consumer asks for a yellow-fleshed potato. In Holland a mealy potato is preferred and in Western Germany a nonsloughing potato is required. We have not been able to find a white-fleshed variety suitable for chip processing. As a result chippers in those countries requiring white-fleshed potatoes must obtain potatoes from contract growers if they wish to make good chips. And if these potatoes are still not suitable in spite of all precautionary measures, the chipper can only sell them for feeding purposes or, if he is lucky, to the starch industry.

Variations in day length.--The differences in day length are much larger than in America. As a consequence a suitable variety in Spain such as Kennebec cannot be grown in Holland or further North. Under our conditions the yield is low and the reducing sugar content is too high for chip processing.

Disadvantages of some suitable varieties.--Most varieties suitable for chip processing have a high dry matter content (more than 21 percent). As a result they are susceptible to black-spot, which results in high costs for trimming. Sometimes more than 10 people are required at the trimming belt feeding a 1500-pound frier.

Storage and earlies.--As required in the USA, chip potatoes in West Europe should also be stored at temperatures of 45° to 50°F. Since we do not have free trade as you have in your country, potatoes must be stored till the next harvest, which means in Holland, Scandinavia and Germany until the end of June or the beginning of July. High prices must be paid for early potatoes as late as July. Storage at 45° to 50°F. is expensive in Europe. Even with cool storage we often do not obtain potatoes with a low reducing sugar content at the end of the storage season. This results in purchasing expensive early potatoes which lower the profits.

Mr. G. B. Beardsley of Meredith & Drew, London, gave an example during a symposium in London last spring. He discussed the budget of a chip manufacturer and compared this budget with actual costs. As a result of unsatisfactory chip quality all contract potatoes had to be replaced by potatoes imported from Greece and Malta in the period 18th May to 15th June. This cost

the company about $40,000 over their estimated raw material cost. Because of lack of early potatoes, the price of the earlies in the period 15th June to 20th July was much higher than budgeted. This cost the company another $40,000. These extra costs over the budget during the whole year amounted to $110,000--which reduced the anticipated profits about 50 percent. This example illustrates the problems of one chip industry.

The chip industry and research.--The West European chip industry has, in my opinion, assumed the only possible attitude regarding these problems. I have already mentioned the valuable advice given by Ora Smith in the early 1960's. Acting upon this advice interested parties have established the Potato Chip Industry's Research Group in 1963. Nearly all West European chippers have joined this group. The annual contribution of each member is assessed according to his production capacity. The greater part of the income is used for the research of our IBVL in co-operation with the Board of the Research Group. Chippers of any country are further entitled to spend 10 percent of the income for supporting the national research on variety.

During the last few years we have, in co-operation with our Board of Management, intensively searched for solutions for the almost insurmountable difficulties of the industry with regard to supply of raw materials.

Microwave.--Technological developments in the USA encouraged us to carry out an extensive program on a pilot plant scale on finish-frying with the aid of the micro-wave heat. These initial experiments were followed up by work in commercial installations. The conclusion has been that microwaves do improve chip quality. The experiments indicated, however, that this improvement is not sufficient so that chip quality could be obtained independently of reducing sugar content. Even if a West European chipper had a microwave oven at his disposal, it would still be necessary to take extra care in purchasing and storing suitable raw material.

Finish drying of chips.--We have carried out research on laboratory scale regarding the possibility of finish-drying par-fried chips by means of hot air. From the point of view of colour improvements, this method was successful. However, as moisture content must be reduced from about 10 percent to about 2 percent, the bite of the chips becomes much too hard. Finish-drying by means of hot air, therefore, could not be applied in practice.

Vacuum frying.--Finally we have carried out some experiments, first on laboratory scale and afterwards in commercial practice, on finish frying par-fried chips under vacuum. If the

vacuum is increased to such a level (70 mm. Hg.) that the temperature of the oil during finish frying does not surpass 212°F., reducing the 10 percent moisture (absolute) to 1- to 2-percent results in no detectable change in colour.

There was, however, a disadvantage at first, namely that the chips when discharged from the vacuum frier absorbed the adhering fat and fat content increased to an unacceptable level (approx. 60 percent). We have found a solution to this. Mr. Sijbring will explain to you later on the construction of the vacuum frier developed by him and his co-workers. He will also report on results of practical experiments.

The construction of the proto-type vacuum frier--carried out by the N. V. Stork-Jaffa at Utrecht and N. V. Florigo at Woerden in Holland by order of the IBVL--has been possible thanks to the financial support of the Ministry of Agriculture and Fisheries and the Ministry of Economical Affairs of the Dutch government. The prototype vacuum frier has now operated at the Smith's Holland Factory for 5 months. As the processing of good-quality sticks (small canned French-fries) raises even larger problems in the late season than the processing of chips, the vacuum frier has mainly been used during the past season for processing sticks. Good-quality sticks were processed from 1967 potatoes with a reducing sugar content of <0.5 percent. One of the difficulties which still exist in this technique is the large difference in dwelling time of the slices in the conventional frier, which in some cases causes irregularity in colour. By taking extra precautions during frying this can be prevented.

In summary I would state that as a result of the above-mentioned technological development, which was accomplished in close co-operation with the chip industry in Western Europe, we have succeeded in:

. . . processing a good chip by means of the vacuum frier from potatoes offered on the normal consumption market in West Europe.

. . . creating possibilities, by applying this frier, for storing chip potatoes at lower temperatures (35° to 40°F.) resulting in a longer storage time and less cost for earlies.

. . . As a result of these possibilities the necessity for chippers to conclude contracts for special varieties with growers shall probably no longer continue.

If we could also succeed in altering the conventional frier so that the final moisture content of the par-fried chips could be better controlled, we would at the same time have reached the goal that a chipper can process from just any kind of potato exactly the colour quality desired by his customers. We would

then hopefully have achieved the goal of complete independence of the characteristics of the raw material as far as these influence colour. The fact that the West European industry has been able to observe progress of research from month to month during the last 5 years has had a favourable influence on achievement of positive results. It is our opinion that with recent technical developments the most serious problems of our chip industry have, in principle, been solved.

PRINCIPLES OF VACUUM FRYING AND RESULTS OF PRACTICE

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Basically, the brown colour of potato chips is formed by a reaction between reducing sugars and amino acids. It is formed when moisture content decreases below 6 to 12 percent. The starting point depends on the frying-oil temperature and on the reducing sugar content of the potatoes. In the finished product however, (moisture content below 2 percent) browning is more or less independent of frying-oil temperature and depends only on the reducing sugar content. If the reducing sugar is high, the chips will be dark brown. If it is low the chips will have a light colour. With lower reducing sugar the discolouration starts at lower moisture content.

To get better chip colours, it is necessary to find a method for drying the chips from 10 to 2 percent in such a way that no discolouration occurs. Frying in oil of 100°C. or lower, with a pressure lower than 7 cm. Hg, is a method for removal of the last moisture without discoloration. If the oil temperature is higher than 100°C., some browning takes place. There is more browning when the temperature is higher. If the pressure is higher than 7 cm. Hg, the chips must remain in the oil longer and the final product will have a higher oil content. A lower pressure does not change the process much.

It is necessary that the chips be taken out of the oil under vacuum. If first the pressure is raised and chips are taken out afterwards, all the free spaces in chips are filled with oil. In this case they are clear as glass. In practice it is found that 10-percent moisture content of chips taken out of the first cooker is enough for right colour in any case.

The vacuum process can be used also for making "sticks." Sticks are a dry product like chips, with a cross-section about 5 mm. square and several cm. in length. Because of the shape of this product, the browning starts at a much higher moisture content. The moisture content of sticks taken out of the first cooker sometimes must be 25 percent to assure right colour. This is quite possible because sticks at this moisture content already have certain rigidity and can be transported easily.

Last year (1967) we attempted to apply the principle of vacuum frying in practice and some preliminary designs were made and studied, finally resulting in the design and building of a prototype of a continuous-working frier with a capacity of 750 kg./hour. At the moment this apparatus is installed in a chips plant, and we have been testing it for several months now.

<u>Frying oven</u>--The frying oven is a cylindrical kettle in which a vacuum can be maintained (figure 1). This kettle contains

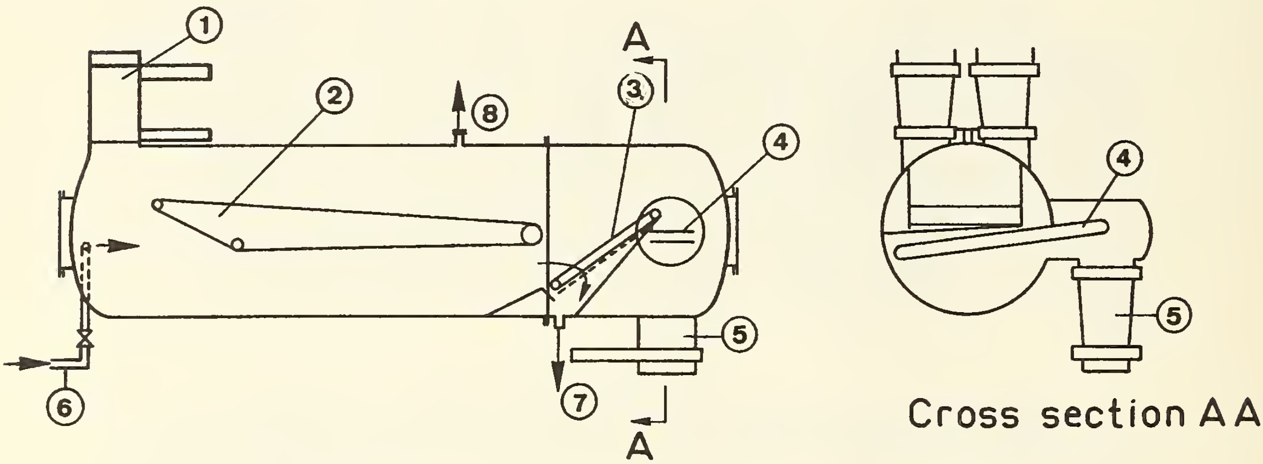

Figure 1. Diagram of prototype vacuum frying apparatus.

the oil to fry the chips. Built-in conveyor belts transport the chips through the oven. The chips going into the oven have a relatively low moisture content and consequently float on the oil. After being transported through the lock (1) into the oven, the chips are pressed below the oil level by a belt (No. 2) which transports the chips through the oven and transfers to belt No. 3. Belt 3 transports the chips out of the oil. No. 4 belt, which fills the lock at the other end, brings the chips into the open air again.

A heat exchanger heats the frying oil, which is supplied through No. 6 pipe. In the future heat of the orthodox cooker will be used for the vacuum process. The water vapor is conducted to the condenser via 8. To enable cleaning the kettle has been divided into two parts. The front part with the supply locks is mounted fixed. The rear part has been mounted on a cart and is movable. All conveyor belts can be removed. Covers are installed at the front and rear ends.

Locks.--Each lock (Figure 2) is provided with two slide

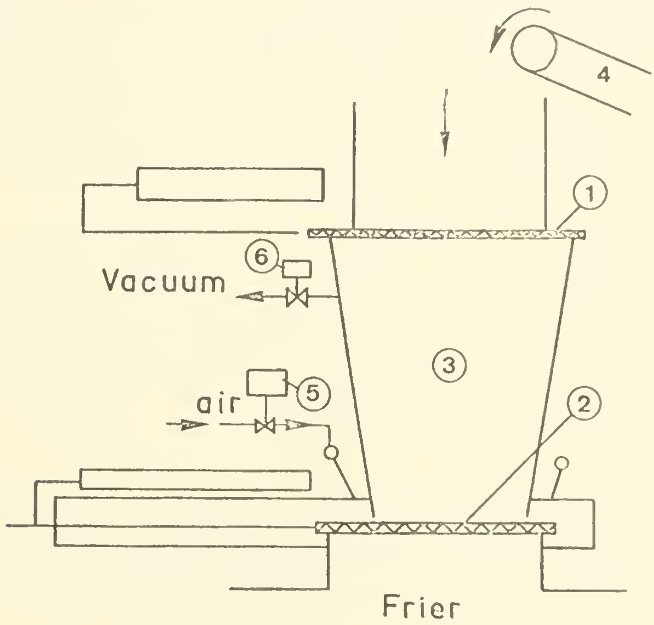

Figure 2. Diagram of a lock.

valves (1 and 2) with a receptacle (3) in between. The supply lock operates as follows: (A) Valve (1) opens. (B) Supply belt (4) runs. The recptacle (3) between both valves is filled with chips. (C) When the recptacle is filled the upper valve (1) closes. (D) The receptacle between the valves (3) is emptied by opening the flap (6). (E) If the pressure in receptacle (3) and kettle are equal the lower valve (2) opens and the chips fall into the oven. (F) Lower valve (2) closes. (G) Air is admitted into the lock receptacle via the flap (5). (H) If the pressure is equal on both sides of the upper valve, the value opens. Because the valves are opened only when pressure is equal on both sides, the operation can be achieved with a minimum of power. Moreover, the valve is constructed in such a way that it first ascends a few millimeters before it opens. Thus the wear on the seal providing the tight closing is restricted to a minimum.

By selecting a flap seating larger than the opening over the valve, one avoids chips falling on the seating. The air inlet is placed on the casing in which the valve is moving. The air for the lock-room has to pass through the narrow gap above the valve, so as to blow possible droppings from the valve into the lock. The valve is also equiped with a brush which cleans the seating at every movement of the valve. Compressed air is used to move the valves.

Frying oil circuit.--The frying oil is heated in a heat exchanger. It circulates and passes in succession through pump, filter, heat exchanger, frier, and pump. Close to each other two filters have been installed, which can be cleaned alternately. Because of the vacuum, supplying oil is an easy matter. By the choice of pumps, expulsion of oil during the process can be effected from its pressure pipe, as at that particular spot the pressure is higher than the atmospheric pressure.

Vacuum system.--Water vapour and leakage air must be sucked off. A mix condenser is installed on the frier. A mix condenser is a container in which water is mixed with water vapour and the vapour condenses. All the water is then removed by a pump. Also an air pump is connected to this condenser. It removes the leakage air and other noncondensable gases.

The description of the locks has shown that the lock spaces must be emptied before each charge or after each removal of chips. A pump has been installed for that purpose. To keep the necessary pump capacity restricted the movements of the supply locks and the discharge locks are regulated in such a way that, when the supply lock is emptied the discharge lock is filled with air and vice versa. By choice of regulation, it is possible to have supply and discharge locks connected with each other for a short time, so that the pressure can be removed. Thus the amount of air discharged by the pump is considerably reduced. The vacuum pumps in use are watering pumps.

Results.--Several tests in a factory have shown that it is possible to reduce the moisture content of chips from 10 to 2 percent without browning. For sticks it is possible to reduce the moisture content to 2 from about 25 percent without discolouration. The quality of the product processed in this way is good. Still there are difficulties to overcome. There are large differences in dwelling time. These differences result in a wide range of moisture contents and also in a wide range of colours.

The oil content of chips processed in the line with the vacuum frier was always somewhat lower than that of chips

processed in the conventional way. In Table 1 some results are given. The numbers for colour are according to the IBVL chips colour score ratings. In this method No. 1 is almost black and No. 10 has no colour at all. Chip colour No. 5 in Europe is almost not salable. In Table 2 some results for sticks are given.

Table 1. Comparison of chips from vacuum processing with those from conventional frier

No.	Reducing sugar content		Chips after pre-frying in Ferry frier	Chips after finish frying in vacuum frier	Chips fried in normal frying line
		Colour	7	7	4
1	0.7	Moisture %	8.1	1.7	1.2
		Oil %	39.7	38.5	42.2
		Colour	7-8	7	4-5
2	0.6	Moisture %	4.1	0.5	2.5
		Oil %	41.0	40.4	46.6
		Colour	7.1/2	7	4.1/2
3	0.5-0.6	Moisture %	6.0	0.7	1.3
		Oil %	40.1	39.2	39.3

Table 2. Vacuum-fried potato "sticks" compared with sticks fried by conventional method

No.		Sticks after pre-frying in Ferry-frier	Sticks after finish frying in vacuum-frier	Normal fried sticks
	Colour	5	5-1/2	3
1	Moisture %	16.7	1.6	-
	Oil %	21.2	26.2	-
	Colour	5	5	3
2	Moisture %	25.6	1.9	-
	Oil %	18.0	27.6	-

The colour scores are lower, but sticks can have more browning than chips and remain salable.

During the whole operating period of the vacuum frier, the oil quality is carefully checked. Because the amount of oil coming into the vacuum frier is almost the same as the amount leaving with the chips, the oil level doesn't change during operation.

There is no "turnover" as in a normal cooker. The only fresh oil coming into the vacuum frier is brought in with the chips. The oil comes from the pre-fryer and is already treated. Tests have shown that the oil quality in the vacuum-frier is always better than the oil in the normal fryer. Peroxide values are always lower and free fatty acids in the vacuum cooker are always very low even after 80 hours of running without refreshing oil.

THEORIES FOR BLACKSPOT SUSCEPTIBILITY IN POTATOES: OLD AND NEW

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A solution to the problem of blackspot in potatoes has been sought since the early 1900's. Many papers on this topic have been presented at earlier utilization conferences. Most of the investigations have tried to eliminate, or at least reduce, its incidence by improving handling procedures or by changing cultural practices. However, blackspot still occurs with dismaying frequency in most growing areas here and abroad and attempts to eliminate it have failed. Either the methods of control suggested were not adequate, or farmers, shippers, and processors were economically unable to follow the recommendations of the investigator.

Other investigations have attempted to relate specific tuber factors to tendency to blacken. The results have proved controversial and conflicting. In this paper, we will describe some of these compositional factors and discuss how they may contribute to susceptibility. We will also review some recent theories and see what implications and extrapolations can be drawn.

Certain varieties appear to vary in susceptibility, but the degree of susceptibility is usually determined by the percent of tubers that show blackspots after bruising. Under the right conditions it has been demonstrated that blackspot can be just as severe in the so-called resistant as in susceptible varieties. Susceptibility seems to depend on the stage of maturity at which tubers are injured, how long tubers are stored, and cultural and environmental conditions experienced by the plants and tubers during growth and after harvest. Therefore, the absence of

blackspot on any single lot of potatoes merely indicates the degree of susceptibility or resistance at that specific time and for that specific lot.

Turgidity of tubers at harvest has been suggested as a factor in resistance. It appears that there is an optimum condition of turgor at which potatoes are quite resistant. As water is lost and turgor decreases they become more susceptible. However, as loss of water continues and cells reach a certain point of dryness the tuber becomes rubbery and once again resistant to blackspot. This pattern is explained by changes in physical structure and response of cells to impact. We now have a study in progress to examine the extent of physical damage by histological methods. Studies to date do not indicate a great deal of actual cell-wall breakage, but we are not yet able to adequately distinguish crushed cells and thus cannot make definite statements as to possible differences in physical damage to cells in resistant and susceptible tissues.

To take advantage of the resistance of potatoes with high turgidity, it is necessary to water right up to vine removal and harvest as soon after skin-set as possible. A modification of this method, by incorporating undercutting of plants immediately after vine removal, has proved very successful in maintaining soil moisture around the tuber while skins are setting and in maintaining low soil and tuber temperature. However, this recommended harvest procedure conflicts with that practiced in other areas of the country, where it is recommended that the soil be allowed to dry for several weeks prior to harvest. One reason for this recommendation is to keep the CO_2 content of the soil at a low level. Water in the soil would only serve to increase the CO_2 in the microclimate immediately surrounding the tubers. Other studies, however, indicated that high CO_2 content in tuber tissue is not a cause for blackspot susceptibility.

Temperature could also vary with soil moisture. A dry soil would tend to warm up faster than a wet soil and a condition known as "deep blackspot," or as stated in some inspection reports, "blackspot that rots to the center," is likely to occur in bruised potato tubers. This is a physiological rot similar to blackspot, but occurring at the surface as a result of bruising of tubers that have been subjected to high temperature. The bruised area first appears as a blackspot on the surface and then the rot penetrates to the center of the tuber. The disorder is not true blackspot. Blackspot does not develop a rot.

Nitrogen, potassium, and copper have also been studied in their relation to blackspot. High nitrogen is usually associated with immaturity, potassium with water uptake, and copper with

phenolase activity. Conflicting and inconsistent data from many investigations, however, still make it impossible to prove the existence of a specific relationship between any of these elements and blackspot. One reason for inconsistent data with fertilizer studies may be the inability to determine accurately the specific mineral content of an experimental plot because of inadequate soil-sampling. Of these three mineral elements, potassium currently seems to offer the greatest possibility of being in some way associated with discoloration.

Since we obviously have not solved the problem, it is time to take a new look at blackspot research. We must formulate and then intensively test new theories and explore new avenues of control, whether they are now practical or impractical from a commercial standpoint. We will discuss a few of these alternative theories we now have under study.

Since phenolases are believed to be the main enzymes involved in the production of melanin pigments, the other oxidative enzymes have not been studied in relation to blackspot susceptibility. Why not? Doesn't peroxidase also have the ability to oxidize phenolic compounds? All that is needed is the presence of minute quantities of H_2O_2. We know that H_2O_2 can be produced in plants by certain enzyme systems and that it could be developed in injured tissue. The early work of Raper on melanin production theorizes the production of H_2O_2 as part of the melanin reaction. If H_2O_2 was present in sufficient quantity, then peroxidase could contribute to the oxidation of phenolics, tyrosine and chlorogenic acid, and contribute color to the pigment already developing and thus add to susceptibility. On the other hand, it might oxidize substrates that would normally be used by the phenolases and thus contribute to resistance. Catalase activity may also be important. It could break down the H_2O_2, or at least a certain amount of it, and thus reduce peroxidase activity. Thus, phenolase activity, even if it does not appear to be associated with blackspot when analyzed separately, could be modified by either peroxidase or catalase in the presence of H_2O_2 and thus be indirectly responsible for blackspot.

If we assume that H_2O_2 is in fact present, and available in sufficient quantity to effect enzyme systems, then we need to know the effect of H_2O_2 on potato phenolases and determine how the phenolase activity can be varied by peroxidase and catalase. Also, changes in phenolase activity could vary with the type of substrate oxidized and this must be determined. In recent studies, just now being readied for publication, we have found that the activity of phenolase in the presence of H_2O_2 varies with the substrate used. With catechol as the substrate, H_2O_2 caused a decrease in polyphenolase activity. On the other hand, with chlorogenic acid, the

main polyphenol found in potatoes, as the substrate there was a rapid increase in polyphenolase activity in the presence of H_2O_2. If H_2O_2 is associated with blackspot susceptibility, then tests using catechol would not present a true picture of phenolase activity as it actually reacts in bruised potato tissues. Hydrogen peroxide reduces the activity of monophenolases when either tyrosine or p-cresol is used as substrate. Thus phenolase, peroxidase, and catalase could, in theory at least, be involved in blackspot and their interactions could influence susceptibility or resistance to the disorder.

If the extent of injury, as thought by many, is actually responsible for the degree of susceptibility, the soluble or particulate association of the enzymes involved in melanin production could influence the effect of enzyme activity on developing blackspot. In recent studies, we have found that approximately 50 to 60 percent of the phenolase activity in the buffer extracts is in the supernatant after centrifuging at 16,000 g. Peroxidase activity, on the other hand, is almost entirely in the soluble fraction. We also found that much, if not most, of the peroxidase activity, and a considerable portion of the phenolase activity, was still bound to the cell wall and could not be removed by high salt, sugar, or urea extraction medias. This bound fraction could be very important in determining blackspot susceptibility. When blackspot tissue was observed under a microscope much of the black color was always found on the cell walls of broken cells. We are actively trying to find a method of quantitatively determining this bound form of enzyme activity.

We know that the bruising of tubers exposed to high temperature can create the penetrating physiological rot (deep blackspot) already discussed. Therefore couldn't blackspot merely be a state of arrested blackheart? Bruising could increase the respiration rate of injured cells so that oxygen in the bruised area could then be utilized faster than it could be replaced through the uninjured tissue. Since tuber temperature is not usually sufficiently high to increase the respiration rate of uninjured cells surrounding the bruised area, these healthy cells have sufficient oxygen to keep them functioning and the physiological rot is thereby limited to the bruised area. We are now testing this theory. If anaerobic respiration does take place it should be possible to detect an increase in either acetaldehyde, or ethyl alcohol, or both. Since the amount of these volatiles would be small the best method of detection would be by gas-liquid chromatography (GLC). Using a 900-foot capillary column for vapor analysis of bruised and unbruised tissue, we have found that both ethanol and acetaldehyde do increase in the bruised area.

Another pathway by which anaerobic conditions could be detected would be lactic acid production. Therefore, a study of the Krebs cycle-associated acids was initiated. First we had to develop a quantitative GLC method capable of quantitatively determining the many Krebs cycle-associated acids in potatoes. We were able to do this, and the results obtained will soon be published. We are now analyzing the Krebs cycle-associated acids in potatoes and have identified 5 or 6 of those found.

These are merely a few of the possible ways by which susceptibility to blackspot could be produced. However, as we work on any one pathway other compounds and enzymes are inevitably involved. We hope that, by careful selection of resistant and susceptible tissues on an individual spot basis and analyzing enzyme activity and the chemical composition from the same tissue after freeze drying, a greater number of individual factors, and their interactions, can be determined and studied through computer analysis. If a factor that is highly associated with blackspot can be found, it might then be incorporated into a breeding program to develop resistant varieties, or it could be used to modify the disorder in the field, or in the tuber, after harvest.

PREVENTION OF BROWNING OFF-FLAVORS IN EXPLOSION-PUFFED POTATOES

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Non-enzymatic browning in foods is well known. There are essentially three types: (1) caramelization, (2) Maillard reaction, and (3) the Strecker degradation. These reactions produce compounds with color and flavor. The right combinations of color and flavor are recognized in the brown crust of bread or the flavor of chocolate. The wrong color or flavor produces a product of low quality, for example dark brown potato chips or off-flavors.

The interaction between amino acids or proteins and reducing sugars causes browning in processing and during storage of dehydrated foods. This nonenzymatic browning shows its presence in several ways. Either the processed food begins to turn tan, or off-flavors develop, or a combination of the two occurs.

Sulfiting, to prevent or retard discoloration caused by nonenzymatic browning, has been used by dehydrators for many years. Quartermaster specifications require 300 to 500 ppm. sulfite content (as SO_2) for dehydrated potato dice. Sulfite protects a product from nonenzymatic browning or scorching during dehydration and increases the storage life.

A form of nonenzymatic browning that sulfiting does not prevent results from the Strecker degradation. This browning is due to a reaction of an amino acid with an alpha-carbonyl compound in aqueous solution. In the potato there are at least 27 identified amino acids. The reaction of any of these with an alpha-carbonyl group produces a flavored aldehyde. Some of their aromas are offensive and they are classified as off-flavor aldehydes.

Originally our chief concern in developing explosion-puffed potato dice was rapid and complete rehydration. This took time to achieve. Intense off-flavors were noted in early taste tests of the products and eventually it became necessary to identify and eliminate these flavors. Cooperation of the Plant Products Laboratory was requested and they undertook the identification and analytical investigations. Gas chromatographic analyses of the vapors of reconstituted potato dice were made. A modification of the technique described by Buttery and Teranishi of the Western Utilization Research and Development Division was used.

The technique employed consisted of adding 15 grams of dried explosion-puffed potato dice to 300 ml. of boiling water in a 500-ml. Erlenmeyer. The Erlenmeyer was stoppered and submerged in a boiling water bath for 5 minutes. A 1-ml. sample of vapors in the head space was taken by syringe and the gas sample was injected into a Perkin Elmer F11 gas chromatograph using a flame ionization detector.

Identifications of the off-flavor components were made by coupling a mass spectrophotometer in tandem with the chromatographic unit. The compounds producing the off-flavor were found to be isobutyraldehyde and isovaleraldehyde. The intensity of the flavor material was measured by the height of the peaks. After indentification of the offending compounds, the next question was: At what point were they being formed or intensified?

A brief explanation of the process is as follows: Potatoes are immersed in 20-percent lye at 160°F. for 7 minutes. The jackets are removed in the spray washer. The skinned potatoes are sulfited to prevent surface darkening. Rot and eyes are

trimmed out and the potatoes are cut into 3/8-inch cubes. Surface starch is washed off and the dice are sized over a 3/16-inch slotted screen. About 12-percent unders are obtained, which are dried separately and do not require puffing. The overs are precooked 20 minutes at 160°F., cooled 10 minutes at 50°F., and blanched 8 minutes. The dice are dipped in 0.5-percent sodium bisulfite solution to give 300 to 500 ppm. in the dried dice. They are dried in tray driers at 200°F. to approximately 27 percent moisture. The partially dried potatoes are equilibrated at 73°F. to obtain uniform moisture. Then to prevent clumping the dice surfaces are coated with 1.25-percent sodium silico aluminate. The dice are loaded into a gun, explosive-puffed, and dried in a tray drier to about 4-percent moisture.

Samples were taken at various points throughout the process and dried to 4-percent moisture. These samples were given to the Plant Products Laboratory for evaluation. In the chromatographic curve obtained from analysis of head-space vapor, the peaks representing isobutyraldehyde and isovaleraldehyde indicated the amounts of off-flavor aldehydes present. From peak heights of the in-process samples it was apparent that the off-flavors are developed during puffing.

Dice puffed in the gun by a combination of internal heating (superheated steam) and external heating (gas flame) were compared with dice puffed by external heating alone for amounts of isobutyraldehyde produced. At the same time dice with and without sulfite treatment were evaluated and we learned that puffing by external heating produced the highest peak. Sulfite-treated dice produced from superheated steam had higher peaks than the untreated. Sulfite-treated dice were white, whereas the Maillard color reaction was evident in other samples. The sulfite had stopped the color reaction but not the Strecker degradation.

The first three methods that were tried for the prevention of off-flavored aldehydes proved impractical or unsuccessful. Leaching to remove the reactants was tried first. It was successful but impractical because, aside from starch, every other ingredient was almost completely extracted. The other two methods were attempts to block the Strecker degradation. One was use of the metal ions calcium and magnesium to open and then bridge the oxygen double bonds of the 1,2-dicarbonyl groups. In the other method we applied the mass action law. We added an excessive amount of an amino acid, such as glutamic, a natural ingredient of potatoes. If this acid would react preferentially, a non-offending aldehyde would form. Both approaches were unsuccessful.

In the Strecker degradation reaction, CO_2 gas is one of the end products. We tried to reverse the reaction by injecting that gas into the puffing gun. In these experiments, CO_2 gas passed through a rotometer, mixed with wet steam, became heated along with the steam in superheaters, and proceeded into the puffing gun. Partially dried potato dice were puffed at four different gas-steam mixtures. Peak heights for these samples showed that at a feed rate of 0.2 pound per minute of CO_2 gas, the aldehydes increased. At 0.5 pound per minute, the peak heights dropped drastically. All samples were reconstituted. Off-flavors could be detected in the first two samples but not in the last two. However, complete rehydration was not obtained for the dice puffed at the two higher gas feed rates. They were not puffed sufficiently at the low steam rate. In another experiment, with CO_2 fed at 0.35 pound per minute, complete puffing and rehydration were obtained with no detectable off-flavors.

To check the possibility that improvement resulted because CO_2 displaced oxygen from the system rather than reversing the reaction, nitrogen was substituted. The same gas feed rates were used and the same type of results were obtained. The isobutyraldehyde and isovaleraldehyde peaks were reduced as the nitrogen feed rate was increased, as they were with CO_2. We reasoned, after the nitrogen experiments, that oxygen displacement was probably responsible for the good-flavored explosion-puffed dice. To further check the contention we speculated that by adding oxygen, peak heights should be as high as a standard or higher. Compressed air was mixed with the wet steam with unexpected results. Contrary to expectation the isobutyraldehyde and isovaleraldehyde peaks decreased as air rates increased. However, a peak having a longer retention time than isovaleraldehyde and not previously detected was observed. It was also observed that this peak increased in height as the air flow was increased. The identity of this component is still under study. Samples of the dice puffed with air and steam were rehydrated and tasted. Off-flavor was detected in all samples but it was a different off-flavor from that normally identified with isobutyraldehyde.

Since in the foregoing tests the oxygen displacement theory was not supported, perhaps steam dilution by CO_2 and nitrogen, both noncondensable gases, might explain improvements in isobutyraldehyde and isovaleraldehyde peaks. The amount of moisture that was available for condensation on the surface of each potato piece in the gun was reduced by the addition of these gases. Less surface moisture might cause the Strecker reaction to proceed at a slower rate. Experimentally an increase in the gas-to-steam ratio reduced the isobutyraldehyde and isovaleraldehyde peaks but as the steam feed to the gun decreased, it became more difficult to

completely puff the potato dice. When steam is completely replaced by CO_2 or nitrogen, no puff is obtained. Steam condensation is needed to supply heat necessary for puffing but it also appears to be the medium for the Strecker reaction. Thus, the process requires a balanced mixture of steam and gas to supply enough energy to puff and to reduce available surface moisture to retard the Strecker degradation.

To check by another means the effect of amount of steam condensation on off-flavor development, charge size was varied while steam-CO_2 rate was held constant. Doubling charge size would have the same effect as reducing steam-CO_2 rate. Results confirmed this, since off-flavors were much reduced as charge size was doubled.

We can prevent browning off-flavors in explosion-puffed potatoes by using CO_2 or nitrogen with superheated steam. This is considered to be a practical procedure. Experimentation will continue to determine underlying principles and to optimize conditions. We will also explore the effects of process variables as well as packing conditions on keeping qualities of potato dice.

THE FOOD SCIENCE DEPARTMENT, UNIVERSITY OF MANITOBA, IN RELATION TO THE POTATO INDUSTRY OF MANITOBA

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Potato Research at the University of Manitoba.--The University of Manitoba has recently created a Food Science Department with programs in education and research. These programs are expected to increase in scope as circumstances permit. The following remarks are concerned with the research and service program on potatoes.

The University of Manitoba is situated in a major potato growing area of North America and is in contact with potato research and development work under way at several centres in North America, United Kingdom, the Netherlands, West Germany, Eastern Europe, and Australia.

The Faculty of Agriculture, of which our Food Science Department is a part, is currently expanding its work on potatoes in breeding, pathology, cultural practices, storage, irradiation

and variety evaluations for processing, and can offer wide technical support to the potato industry. Research will continue in these areas, including potatoes for chipping, and where possible the Department will assist by trying to develop techniques for chemical "finger-printing" and screening of potatoes, better techniques of evaluation for processing quality, and so on. The Department will act as the liaison group between the industry in Manitoba and those concerned with producing this crop. The Department of Agricultural Engineering will assist with work on storage design, and it is hoped that it will soon be possible to appoint a full-time post-harvest physiologist in the Department of Plant Science to assist in storage work. Considerable work has already been done here on the irradiation of potatoes by Professor Menzies and his associates.

Several potato projects are planned for the future by the Department of Food Science in co-operation with other Departments. Our current work is divided into three main areas. Some reasons why we rate these topics important are given below.

Potato chemistry versus quality.--We must all take a closer look at the specifications we have drawn up for potatoes to be used for processing. For instance, we should be looking for potatoes which meet all the major screening criteria for quality, but which can also be peeled more easily with less wastage and less water usage. They should be of such chemical composition that they will not be prone to the problems such as excessive darkening during frying, after-cooking blackening, rapid browning after peeling, and excessive tendency to cell adhesion during flake manufacture. As far as possible, they must also be rich in natural antioxidants and other constituents such as sequestrants, so that the shelf-life required of the products made from them can be maintained under commercial marketing conditions without any appreciable addition of synthetic anti-oxidants, etc. German potato processors are currently meeting stringent regulations that do not permit certain additives, and processors in other countries must prepare to meet similar regulations.

The industry has too often tried to put the fire out after it has occurred, by such processes as addition of various agents during processing. But I suspect that in years to come these practices will either not be allowed or be technically unnecessary most of the time. Techniques for the chemical screening of potatoes during breeding and cultural trials need to be greatly improved. The pattern of distribution of certain constituents, both qualitatively and quantitatively in some crops, such as corn, peas, beans and rhubarb, leads one to hope that we can develop useful techniques for chemically "finger-printing" lines

of potatoes during their development as possible processing varieties. If composition can be adequately correlated with genetical make-up and cultural history, then we should be able to minimize many of the chemical problems which currently complicate potato processing by producing raw material which will be chemically more suitable for our purposes.

Accordingly, we will begin work next year on simpler techniques for the chemical "finger-printing" of potatoes, particularly of the polyphenol constituents. Several varieties grown under known regimes of fertilizer levels and irrigation in Red River potato districts will be sampled and analyzed. Attempts will be made to correlate genetics, cultural history, chemical composition, and processed quality. A lot of data will be collected before the trends in these relationships can be discerned. We would welcome support on this type of work.

Potato physiology.--We know little about the life processes of the potato, particularly of the tubers during formation and storage, and how they are influenced by genetic, cultural, storage, and sometimes by processing factors. It is fortunate that simple means (irradiation or chemical treatment) have been found for the control of sprouting in stored potatoes. Yet we have little real understanding of what these agents are doing to the physiology of the tubers. We hope that similar treatments can be developed which will enable us to avoid most of the starch-sugar problems which bother the potato industry, particularly chip manufacturers. We condition large quantities of potatoes annually at great cost in yield of solids obtained per ton when processed, in overall weight recovery, in product quality, in time and in conditioning plant costs.

Several years ago the industry should have initiated a physiological research program with a view to acceleration and later the deletion of the conditioning step, except perhaps in emergencies. Our objective should have been to learn much more about sugar-starch metabolism and respiration reactions as a prerequisite to the development of a chemical control method, preferably involving a natural constituent of tubers, or a related substance, for preventing the formation and accumulation of reducing sugars. Close control of storage conditions and conditioning processes, when needed, have usually enabled the desired degree of chip colour control to be achieved. Microwave ovens appear to enable the colour to be controlled well without having to keep reducing sugar levels below 0.3 percent, but it may still be possible to block the reactions involved in sugar accumulation and avoid the need for microwave ovens. Some biochemical research is now proceeding at a few centres in Canada and USA in relation to starch-sugar problems in potatoes.

In comparison to the costs which high reducing sugars cause the potato industry annually, the present research effort on potato physiology is far too small.

As yet we do not know how to determine, in a simple way, the physiological age of a potato tuber at any stage of its life, yet throughout the potato industry we daily make decisions which depend on our having a reasonable knowledge of this matter, and which involve considerable sums of money. Adequate knowledge would enable us to improve our selection and storage procedures, ultimately leading to a system for the prediction of storage life of particular lots. It is common knowledge that potatoes rapidly deteriorate at a certain stage of storage, and if we could delay or predict this turning point the industry would have much better control of quality and costs. When we can small potatoes, we have no means other than size or the "can and see" approach for deciding which to select and when to cease canning "new" potatoes. Dramatic quality changes can occur during maturation, and it is essential that we learn how to predict changes.

Currently, we are sharing a 3-year contract from Atomic Energy of Canada Ltd. with Professor La Croix of the Department of Plant Science for a study of the relationships between irradiation and effects on biochemical systems of the tuber, particularly the starch-sugar system, and on quality of processed products. Additional funds are being sought for further work on potato physiology.

Water and waste problems.--The regional survival and growth of the food industry, particularly the potato industry, is becoming more dependent on prompt solution of problems of water and wastes. Food processing begins and ends with water problems. The costs are an important part of the overall costs. The quantities of water currently used per ton of product for most food processing operations are usually excessive 1/ and the quantities of physically, chemically, and microbiologically polluted water produced are correspondingly larger than necessary. The squandering of large quantities of water during processing and the discharge of large quantities of polluted water must soon cease, because of (a) the need to conserve supplies to permit greatly increased food production and (b) the crippling costs which plants will have to carry if they are to meet the requirements of pollution abatement authorities.

1/ Gallop, R.A. 1966. Record 4. Proceedings, International Symposium "The Utilization and Disposal of Potato Wastes," New Brunswick Research and Productivity Council, Fredericton, N.B., Canada. 464 pp.

Some food processing plants in UK, including potato plants, are currently being forced to install tertiary purification treatment for waste waters, or to relocate or shut down their plants. Plants in countries with less serious water problems than Britain have been given fair warning. If our knowledge of water conservation and of scientific and engineering principles involved in dealing with organic wastes does not increase as fast as pressure of enforcement increases, then our industry must install treatment plants which will be much less efficient than they should be, much larger than they should be, and correspondingly much more costly, during the next 5 to 10 years. It seems that primary treatment will be mandatory throughout the USA within 5 years, and it is likely that secondary treatment will have to be installed within 8 to 10 years. Plants in many areas already must meet these requirements.

The principle is now well established that industry must meet the costs of appropriate treatment of industrial effluents in one way or another. A small investment made now in re-evaluating (a) our raw product handling procedures, (b) our food processing procedures, and (c) our waste disposal systems, in relation to sound scientific and economic criteria, will undoubtedly mean large savings. Reduction in costs will often prove to be easier to achieve and can become a greater factor in the stabilization or increase of profits than would be a heavier investment in product development or sales promotion.

It has been decided that research on water and waste problems will be an important part of the Food Science Department's activities and will be integrated into its teaching program. Our work will have a positive emphasis aimed at conserving water during processing, exploring re-use of water, recovery of by-products of wastes, reclamation of water which has become unfit for food processing operations, and finally the development and improved techniques for the removal of wastes from water, and for destruction of unusable materials.

Our laboratory has just been completed, and shortly we will be exploring the effects of intense gamma irradiation and various chemical and biological procedures on the soluble and colloidally dispersed materials present in potato wastes, under model system conditions. We expect that within a few years a research pilot plant for studies on water use will be available on campus, so that promising methods can be scaled up, in cooperation with the engineering staff. We are currently seeking financial support to extend this work rapidly.

<u>Technical assistance work</u>.--We are anxious to help the potato industry in any way possible, for instance, with answers

to technical enquiries on processing matters or with "trouble-shooting" work. We would be pleased to undertake research for the industry on short or long-term projects.

POTATO RESEARCH IN AUSTRALIA

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It must be realized that Australia, with its population of 12 million, grows an acreage of potatoes approximately the same as California's. Averages for the five-year period ending in 1966 are listed below. (The ton in this table is 2,240 pounds.)

State	Area thousand Acres	Production thousand tons	Yield tons per acre
New South Wales	22.9	99.1	4.3
Victoria	37.3	215.1	5.8
Queensland	15.5	85.4	5.5
S. Australia	5.5	51.6	9.3
W. Australia	6.2	58.3	9.4
Tasmania	11.4	70.8	6.2
Totals	98.9	580.3	5.9

These figures represent a drop from the previous period of 8,000 acres but an increase in production of 108,000 tons. Consumption in Australia has varied considerably, similarly to the United States. It now averages between 110 and 120 pounds per head per annum. In 1960-61 when production was only 450,000 tons, it was as low as 87.8 pounds but in 1962-63 when production reached 666,000 tons, consumption rose to 123.8 pounds. In recent years it has remained at about 110 to 115 pounds.

Prices vary considerably from season to season, particularly on the Sydney market, which is the largest. They have been as low as $1.50 and up to $18.00 per hundredweight. Only three States now have marketing boards, the other States having decided by a poll of growers to abolish theirs. The board in one State is very powerful in that it controls both acreage and the return to growers.

The varieties used are almost solely of North American origin. In the Eastern States, the most popular are Sebago, Sequoia, and Kennebec for processing. In Tasmania, Brownell and Bismark are most favored, in Western Australia, the Delaware, and in South Australia, Pontiac. In New South Wales, varieties bred by the Department of Agriculture occupy between 20 and 25 percent of the average while Sebago occupies about 60 percent.

Potato breeding.--There is no national potato breeding scheme such as you have here in the United States. New South Wales, Victoria, and Tasmania maintain their own breeding and introduction programs. Other States rely on testing both introduced and new varieties and seedlings produced by the three States mentioned.

The NSW program has produced a number of varieties over the past 30 years and the latest have made places for themselves in the NSW growing industry, and one newly named variety has shown great promise in South Australia. The basic aims of breeding programs in Australia are essentially the same as those in North America, in that we require yields at least as good as present varieties, improved shape and appearance, improved quality and disease resistance, and less susceptibility to physiological disorders such as brown fleck, hollow heart, growth crack, and second growth.

The breeding methods used are essentially the same as those used in most North American programs. Seedlings grown from true seed are produced in glasshouses and where applicable tested for resistance to late blight or potato virus X. A limited amount of selection on agronomic qualities may be done at this stage. Most selection for agronomic characters is performed from the second year onward. New South Wales also does some testing in the glasshouse for resistance to common scab.

Little use has been made of wild species as parental material, though of course, we do use overseas breeding lines developed from wild species. No work has yet been done with haploids. However, thought is now being given to the possibility of having one central potato breeding station to serve all Australian States. Briefly, the work of this station would be to produce true seed and seedlings at the request of various researchers, to sort out available parents and test new overseas lines, and to initiate more basic work such as the use of wild species and haploids.

Potato quality research.--Potato processing in Australia is in its infancy, though increasing at a rather rapid rate. Ten years ago the industry would have been worth about $2 to 3 million

while now potato chips alone are worth $22 million. The call for other types of processing is not yet as great. We estimate that approximately 9 to 10 pounds of potatoes per capita are consumed in processed form.

Research into potato quality is also naturally in its infancy. New South Wales, Victoria, and Tasmania have each started programs particularly designed to test potential of present varieties and advanced seedlings for processability. Potato chipping companies have also become much more interested in quality research and most have employed qualified people to work in this field. They are also assisting government researchers in many ways. Each State also has the opportunity of having its advanced seedling lines tested by a trained tasting panel set up by the C.S.I.R.O. New South Wales, for instance, would not release a new variety unless it compared favorably with our standard Sebago in these tests.

<u>Seed certification, mother seed production, etc</u>.--Certification, together with the advent of new improved varieties, has been the biggest factor in increasing yields in all States of Australia. Certification schemes were initiated by at least three States in the early 1930's, with the aim of improving the seed standard of the then popular varieties Factor or Up-to-date, Carmen, etc. Most of these old varieties set numerous small tubers, which were normally used as seed. Despite the fact that these old varieties were very susceptible to virus diseases, marked yield increases were obtained from certified seed.

Besides the certified schemes (which most States operate), three States also operate approved seed schemes which are not intended to replace certified schemes but rather to provide an additional source of good seed. Requirements are not as strict as for certified seed but experience has shown so far that most producers of approved seed rely on certified seed as a basis for their seed crops.

Until recent years it was possible to brand any sack of small potatoes, no matter what the origin, with the words "seed potatoes" and sell them as such. Now, however, new grading regulations are worded so that any sack of potatoes branded "seed" must be the produce of a crop that has been inspected by an officer of the Department of Agriculture in the state of origin. In other words, seed potatoes branded and marketed as such must be either certified or approved.

The three main seed-producing States have come to realize that one of the best ways of ensuring good seed is for the Department of Agriculture to provide the nucleus of all seed

stocks--in other words a "mother" or "elite" seed scheme. Indeed Tasmania has been doing this for some years by way of selection, testing and multiplication of clones at their research station. New South Wales, after a period of selection and testing, is this year releasing the first of its "elite" seed, based on tuber indexed stocks.

In Victoria, researchers are working on a scheme to produce "pathogen-free" seed stock of all varieties. This scheme should be in operation in the near future. At least two and sometimes more inspections are carried out on the growing crop. A final inspection and sealing of the bagged potatoes is done in NSW and Victoria. At this inspection the tubers are checked for diseases such as Rhizoctonia and common scab, for trueness to type, and for compliance with the grading regulations. Growers are then issued labels with their name and the signature of the inspecting officer, and the bag is then sealed with label attached.

The major problems with seed production in Australia are virus diseases, particularly leaf roll and occasionally the Y virus, the fungus diseases (fusarium wilts), and the bacterial disease (blackleg).

Fertilization.--All States have carried out intensive factorial trials to determine best fertilizer practice, and most growers can be given a fairly accurate guide to their fertilizer requirements. However, in many areas there has been a rapid shift from dryland to irrigated culture, which has brought changes in thinking on fertilizers. More consistent responses can now be expected to added nutrients, particularly phosphorus. This development, together with others, has called for more specialized criteria to evaluate responses to added nutrients. Measurements must include not only gross and marketable yield but also tuber numbers and size and those attributes under the general heading of "quality."

Phosphorus is probably the most important single nutrient in Australia potato production. Rates used vary from say 20 pounds per acre to 200 pounds or more in soils where fixation is almost abnormally high. The form most readily available and mostly used is superphosphate (22 percent). With nitrogen, very little difference has been found between sulphate of ammonia, urea, and calcium ammonium nitrate. The first is preferred for use at planting time and the second for application with irrigation water. Except for sandy irrigated soils, no benefit has been found in splitting the application of nitrogen. Potassium is usually applied with the other nutrients, though it appears that application can be delayed or even applied prior to planting. Soil analyses have shown that they should enable a reasonably

accurate determination of potash requirements. In most Australian potato soils only minimal dressings appear necessary. Of the other elements only maganesium and calcium appear to offer any potential for various purposes and these only in particular soil types.

Irrigation.--In Australia, potatoes might be called a latecomer to the ranks of irrigated crops and little work has been done to determine their water requirements. As a result, recommendations have been based on overseas concepts and experimentation, and on work with other crops in Australia. Recent years, however, have seen a rapid expansion of irrigation in most Australia potato areas. Three States irrigate practically all potato crops, two are rapidly approaching 50 percent irrigation, and the other about 30 percent on an acreage basis.

Research into irrigation requirements is now rapidly increasing. Work is being devoted to problems of exactly when to irrigate each variety and how much water to apply at each irrigation. Much irrigation practice has been based on the early flowering stage as the critical time for water application. But Tasmanian work has shown that, particularly with Kennebec, and also with other varieties, application at tuber initiation is most important. Other Australian work has been devoted to estimation of amount of evapotranspiration and hence the amount of water necessary to bring the soil back to field capacity. The Tasmanian Department of Agriculture initiated an irrigation prediction service in 1965 with the cooperation and guidance of the Bureau of Meteorology. The water deficit is calculated each week, and an estimate is broadcast on local radio for use by farmers in determining their irrigation requirements, after allowance for rainfall during the week. The use of lysimeters is being considered.

Weed control.--In Australia, most weed control is achieved by cultivation, rarely as yet by herbicides. Ridging is carried out to control weeds and protect tubers. Experimental work on weed control with herbicides is now in progress but few recommendations have been made. Vine killing is practiced in many areas but this is mainly an aid to harvest by dusting the tops and weeds. Preliminary results indicate that linuron would be a safe recommendation for most areas at a rate of one pound per acre.

Seed handling and treatment.--Most Australian growers realize the advantages to be gained from using small round seed from a reliable source. They also realize that such seed must be produced under very high certification standards. However, because of the shortage of such seed and the cost of purchase,

intensive cutting of larger tubers is practiced particularly with the spring crop. Growers of the autumn crop are reluctant to cut and prefer to use the small tubers from their commercial spring crop.

Most cutting has been done by hand although cutting machinery is gradually increasing, particularly as acreages become larger. Cutting is usually done immediately before planting as growers prefer to allow a well prepared moist seed bed to perform the necessary healing of cut surfaces. Chemical treatment of cut seed is not common in Australia. Work in South Australia, however, has shown that Captan dust can be very useful as a protectant for cut seed, particularly where soil conditions are not suitable or where the cut seed must be stored for even a short period. Interest in the cool storage of seed has also grown in recent years.

Insect pests.--The outstanding insect pests of potatoes in Australia are the potato moth (*Phthorimaea operculella*) and the green peach aphid (*Myzus persicae*), the latter being by far the most important vector of leaf roll virus. Both are introduced species. Control of potato moth has been achieved recently with insecticides such as DDT. However, in some areas resistance to DDT and other organochlotine insecticides has now developed. Recent laboratory work in Queensland has confirmed the development of resistance to DDT, TDE, endrin, dieldrin, lindane, and isobenzan. This has led to increasing use of organophosphorus insecticides such as azinphos, which provides effective control. How long it will take potato moth to become resistant to azinphos and related compounds remains to be seen.

Biological control has not been thoroughly explored. Several newly discovered South American parasites of potato moth have recently been introduced by our Commonwealth Scientific and Industrial Research Organization and improved methods of mass-rearing them have been developed. These parasites are now being released in selected areas, and there are good prospects of at least some of them becoming established and contributing to the control of potato moth.

Storage.--The storage of potatoes for seed or fresh market is possibly one of the most neglected areas of potato research in Australia. The main reason is that the climate of our main potato growing areas is sufficiently mild to require only the minimum of protection. Some loss of cooking quality must occur but this is rarely sufficient to make the produce unacceptable. Glassiness can often occur in potatoes left in the ground over winter and harvested in late winter or early spring. However, now that processing is establishing itself many requests for research into storage problems have been received and a number of insulated

stores have been built. The recent visit of Professor Walter Sparks from Idaho also created interest in storage of potatoes for seed, domestic market, and processing. Research has now been initiated in a number of areas.

FREON 12, A NEW CONCEPT IN FOOD FREEZING

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In three decades food processing by freezing has reached a level in excess of 10 billion pounds per year and is surpassed only by the canning industry. During this period the quality of frozen foods has been excelled only by the fresh product itself. However, in recent years food technology has advanced and the gap has been narrowed. With new development tools to work with, the quality of frozen foods can be as good as, or even better than, the fresh product the consumer is used to.

Since foodstuffs continue to ripen and degrade, often the foods received in the markets are not as desirable as when picked and eaten at the optimum time. Therefore, if processed and frozen when all aspects of food value and acceptance are at a maximum, the food can be better than fresh product.

The 1967-68 Directory of Frozen Food Processors indicates there are 2,884 processors putting out 4,513 different brands of foods. These are divided into the following categories:

361 processors	of fruit and fruit juices
222	of vegetables
529	of fish
406	of shell fish
319	of beef, lamb, and other meats
21	of special meat, including wild game
210	of chicken
121	of turkey
58	of duck
637	of food speciality items

Trends indicate that frozen food sales will rise 150 percent by 1976, from $6.3 billion to $15.4 billion. Average per capita consumption of frozen processed potatoes was 7.5 pounds in 1966, and, if the present trend continues, it will be over 18 pounds

in 1976--an increase of about 150 percent. In 1966 1.5 billion pounds of frozen potato products were produced; and in 1976 almost 4 billion pounds will be processed. This reflects a 250 percent increase. In 1966 sales of frozen potato products were about $320 million; and in 1976 the sales are estimated at nearly $900 million or up to 270 percent of the 1966 volume. Other interesting 10-year predictions, in percentages, include: frozen prepared foods, up 355; frozen meats, up 185; frozen sea foods, up 154; and frozen poultry, up 22.

I want to report a new wrinkle in a chemical we have had for a few years, Freon 12. Freon is the registered trademark of DuPont for its fluorocarbon products. Freon 12 refrigerant has been used quite widely for a long time in closed refrigeration systems. Recent studies by DuPont and many food processors and private laboratories have shown that Freon 12 has great potentials as a direct-contact liquid refrigerant. The temperatures of the Freon 12 are generally -21° to -30°F. when used for direct spray, flood, or immersion. These temperatures are similar to those in conventional blast freezers but the freezing rate with Freon 12 is much faster because of the faster heat transfer to liquid than to air. Freon 12 has been approved by FDA and its certification as food grade appears in the Federal Register. DuPont now markets Freon food freezant, a high-purity grade of Freon 12. It is dichlorodifluoromethane (CCl_2F_2), molecular wt. 120.93, boiling point, -21.62°F., freezing point, -252°F.

The unusual combination of properties found in the Freon compounds is the basis for their wide application and usefulness. They are high-density materials with low boiling points and low surface tension, high molecular weight and no flammability. The high molecular weight also contributes to low vapor specific heat values and fairly low latent heats of vaporization. Freon compounds do not conduct electricity and in general have good dielectric properties. With Freon 12 heat exchange is extremely efficient. The vaporizing Freon 12 carries the heat away from the food, with no need for the imput of mechanical energy such as is needed in pumping liquid or moving air. The latent heat of vaporization is 71 BTU per pound. Thus for a pound of food product, the removal of 180 BTU will result in the evaporation of approximately 2.5 pounds of Freon 12. A simplified expression that has been found satisfactory for calculating the number of BTU to be removed per pound of product is to assume you are dealing only with the water in the product. The product to be frozen is 80 percent water. Thus we are freezing 0.8 pound of water per pound of product. The imput temperature is 70°F. and the frozen product temperature will be -20°F.

(1) $75° \longrightarrow 32°F.$ = 43° x 0.8 = 34.4 BTU
(2) Heat of fusion of water = 143.4 x 0.8 = 114.7 BTU
(3) $32°F. \longrightarrow -20°F.$ = 52 x 0.5 x 0.8 = 20.8 BTU
Total BTU = 169.9 BTU.

DuPont reports the following foods with approximate contact time in seconds to reach 0°F. with Freon 12 used as freezant:

Apple wedges	90	Strawberries	120
Asparagus	45	Potatoes boiled diced	45
Broccoli spears	60	Potatoes French-fried	60
Green beans	60	Potato puffs	300

Other foods reported to have been successfully frozen in or with Freon 12 are meats, seafoods, poultry, and bakery products. The approximate contact time as listed above is to bring the product to 0°F. and is dependent upon product shape, size, texture, moisture content, and temperature of the Freon 12.

We have successfully frozen many food products, and we are in close agreement with approximate times reported above. Our taste panel has indicated as good quality with several potato products as we obtain with conventional blast freezers, and even better quality in some cases.

We have experienced some trouble with splitting of products, which results from too rapid freezing, confining all the heat to the center. The result is pressure build-up which causes a rupture. Most of these difficulties can be overcome by interrupted freezing cycles that slow down the rate of freezing.

To date our studies have been confined to a "bucket type" of freezing apparatus. With this small unit you can determine the contact time and sequences needed to effectively freeze with Freon 12. Freon food freezant is fairly expensive. Systems that are undergoing development will be almost totally closed with as little Freon loss as possible. In conclusion and speaking in rather broad terms, Freon 12 freezing by direct contact results in: (1) cheaper process costs than nitrogen freezing, but more expensive than mechanical blast freezing, (2) ultra quick freezing, (3) reduced dehydration losses, (4) better quality, (5) reduced "drip loss" on thawing, (6) particulate IQF type of freezing, (7) breaded products are frozen without damage to breading, (8) less product damage (no air blast, instantaneous crusting), (9) less coil frosting, and (10) less belt sticking.

A NEW CONCEPT FOR ACCELERATING DRYING IN FLUIDIZED BED

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A little-known technology of controlled resonating combustion with pulsating flow control may be useful in drying systems in the potato processing industry in particular and the vegetable drying industry in general. Sonic-jet systems were explored primarily in aerospace programs under military sponsorship. The flow of new technology from military-funded aerospace programs to the slower developing industrial and agricultural sectors of the nation's economy is not always easy. Our company is, therefore, concerned with the task of accelerating the transfer of sonic-jet technology to a variety of commercial applications. These have included the lower-cost and higher-quality processing of wastes and offal from meat packing plants into meat-and-bone meal, fish and scraps into fish meal, and poultry offal into poultry meal.

Several advantages that spring from the applications of our technology to dehydration problems are summarized as follows: (1) Although sonic-jets with no moving parts are simple engines and blowers they convert fuel energy directly to heated, moving air with high efficiency. They can simplify and improve the atomization of sprayable slurries and handle sticky slurries and particles in a superior fashion. (2) Sonic-jet applied to fluid-bed, air-lift, and spray dryers match the best features of several dryers in use today, with these advantages: broad material applicability; lower capital, operating and maintenance costs; many times (2x to 10x) faster drying rates due to pulsating pressure, vibrating heat-transfer and mass-transfer (valuable effects of broad-band noise); and improved conveying of sticky materials. (3) In addition to the foregoing advantages applying to new types of dehydrating systems, which result in savings in capital expenditures, maintenance and operating costs, similar advantages and savings may also accrue when sonic-jets are used as replacement heat-transfer and mass-transfer devices and air-moving sources in other conventional dehydrators.

Mobile units.--Because of the shortness of harvest seasons and the perishability of many raw products after harvesting, (a) the cost for amortization of processing plant equipment per ton of product is quite high, and (b) it is becoming exceedingly difficult to get capable operating personnel for such short periods of employment. Our firm has explored the possibility of

portable (field-size) trailer-mounted processing rigs. Our preliminary designs and economic studies indicate that the simplicity and low cost of the basic sonic-jet systems may make such mobile units practicable.

Fundamentals.--Intermittent and resonant jets issue from valveless pulse-jet combustors and drive through the jet pumps like one-way jet pistons. This is a very complex phenomenon, and I will not repeat my description of the cycle herein but rather refer to references 1, 2, and 3, listed below. Some of the fundamentals and advantages of sonic and ultrasonic drying are described in reference 4. In our own studies we have depended heavily on reference 5 with respect to the requirements of food drying in general, and on reference 6 for a convenient and detailed description of potato processing.

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DEVELOPMENTS LEADING TO BULK TRANSPORTATION OF POTATOES

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If I told you that you could deliver 90 tons of potatoes in one rail car at one time, I could understand why you would be somewhat surprised. Ninety tons in one car are a lot of potatoes, more than three times the size of present-day shipments by either sack or bulk, almost four times larger than present freight rate minima. It may seem far-out but that is the type of thinking it takes to achieve economic transportation today.

Our proposal is a reality. We can deliver and have delivered 90 tons of potatoes, in top condition, in ACF's new Center Flow bulk produce car. Now some of you may ask, "What am I going to do with so many potatoes at one time?" Believe it or not, based on trial shipments and hundreds of conversations with people in your industry, you have indicated you are ready--and in fact need--a rail car which offers high payload and superior protection for your produce. In addition to maximum payload, ACF's new car is equipped with automatic diesel-electric powered heating, air conditioning, and forced air circulation. You merely set the thermostat and every potato in the car will be uniformly controlled to within a few degrees of the temperature setting regardless of weather.

Before I go into too much detail, I'd like to give you a little background on your new car. It was introduced six years ago and today there are more than 25,000 on the rails. They are recognized by their distinctive clean look and inverted pear-shape design. Another unique feature is versatility. With its variety of sizes, outlets, and loading hatches, it has scores of combinations suited to over 700 different bulk ladings. And one version of the car is insulated to protect the lading from ambient temperature extremes.

About a year ago a major railroad was discussing new concepts in bulk transportation with ACF Product Planning Department. When they heard about the insulated car they asked us if we had ever considered shipping potatoes in it. We started to talk to people about shipping potatoes in bulk in a covered hopper car. In addition to discussing the idea with major growers, shippers, and receivers, we also approached the United Fresh Fruit and Vegetable Association, the National Potato Council, and the U.S. Department of Agriculture. Almost immediately we captured the interest of a major potato handler and chip processor. They were very concerned with cost and had already proved to themselves

that handling potatoes in bulk could save money. Just as important to them, of course, was quality. They wanted potatoes in good condition, without cuts, bruises, or rot, potatoes that had been cured by storage in pre-determined uniform temperatures so that they would made a satisfactory chip. They were extremely interested and agreed to work closely with us in developing the idea and educating us and the railroad regarding the techniques of good handling.

The first thing we learned was that you just don't insulate a covered hopper car and expect it to do a good job with potatoes. To come up with a car combining the best features of every known method, we decided to investigate every existing method of shipping potatoes. To start with, we knew that shipping in bulk wasn't a new idea. Over 500 bulk rail cars are in this service already. They are small insulated ice-bunker box cars which have been converted to bulk handling through the installation of mechanical conveyors. Now these cars have done a good job and did bring about the transition from sack to bulk handling. However, they have certain limitations. The chain conveyors are permanently attached, restricting use of the car to this kind of service. Since a load of potatoes contains about 5 percent dirt, the dirt gets in and around the conveyor, causing major cleaning and wear problems, and while the temperature control is good, it is not precise. The cars rely on wheel-driven fans, ice bunkers, alcohol burners, and vents. The controls do not compare with today's automatic temperature-regulating equipment and cannot compensate quickly for major changes in ambient conditions. Furthermore, the car is small by today's standards. Payloads of 50,000 pounds do not provide sufficient revenues to encourage railroads to invest in new and better equipment. We also took a look at highway transfer of potatoes. Many potatoes are hauled in bulk in trucks. Like our new rail car, these trucks load through the top and unload through the bottom and they do a very fine job.

Next, we looked at the countless loading sites and receiving plants to make sure that we came up with a car that would meet the real needs. In the end, the final criteria were: (a) We wanted a large car, capable of loading up to the full available rail capacity. This meant a payload of approximately 100 tons. (b) The car's quality control system had to be as close to perfect as possible. It had to be as good as, and preferably better than, that provided by the best storage system. (c) We wanted a car that wasn't limited to potatoes, but could handle any bulk lading without change of fittings or special cleaning. (d) Finally, price and delivery were important. In addition to having a reasonable price, it had to be a car that coud be ordered without being committed to a 500-car production run.

After much consultation and consideration with key industry and railroad personnel, a 4600-cubic-foot insulated Center Flow covered hopper car evolved. The car can hold 180,000 pounds of potatoes or other bulk lading in its three hoppers. It has a diesel powered generator which provides electricity for complete air conditioning, heating, and forced air circulation system. Air is drawn off the top of the car and then cooled or heated. It is then forced into the bottom of the three hoppers so that it flows upward uniformly through the potatoes.

It is interesting to point out that this is one of the many areas where the advice of you potato experts came into play. We used fairly high pressure fans in this car to force the air right up through the potatoes as you do in your own storage warehouses. We used a minimum of one cubic foot of air per minute for every 100 pounds of potatoes. I'd like you to keep these two points in mind since they are an important consideration in the quality control results.

No doubt you are curious about the results of our tests to date. In our first test we loaded the car half way with only 88,000 pounds of potatoes. The car was then thoroughly instrumented and placed in a chamber where the ambient air could be controlled from 0° to 130°F. Actually, we intended to hold the temperature between 0° and 100° but by pure accident we went well over 100° at one point. The significant thing is that we always held the potato temperature in the car at the desired 60°F. Temperatures at over 60 individual locations were recorded. We also placed 30 sample bags of potatoes in various parts of the car to determine the quality at each location in the car.

Results of our first test indicated that potato temperature can be maintained at any desired level above 35°. Since that first test, more than half a dozen loads have been shipped from various parts of the country and with payloads ranging up to 182,000 pounds. The results have always been the same. Temperature control is within a few degrees and quality improved during shipment based on before and after chip color comparison. In fact, we have been able to correct certain deficiencies. In one case the potatoes were moist on the surface, and we were able to dry them enough in transit to improve both appearance and handling. In another, the chip color was on the dark side upon loading. We set the temperature at a higher level as directed by the shipper, and improved the chip color in transit.

Now, let's consider loading and unloading the car--a major concern to potato shippers. The car is loaded through the top. An insulated hatch cover 20 inches wide by about 15 feet long covers each of the three compartments. The potatoes are conveyed

to the top of the car and gently lowered into the car through a baffled chute or on a vertical conveyor. In our experimental shipments we used a conveyor and baffled canvas chute. The potatoes drop down through the zig-zag baffles in the chute so that they move fairly gently to the botton of the car.

We understand many trucks are loaded this way. But there is a better way for high production rates. Instead of a canvas chute, you can purchase long vertical conveyors similar to the box loaders used in many chipping plants. These conveyors will carry the potatoes down into the car and automatically retract as the car fills up.

Unloading the Center Flow is just as simple as loading. The car is equipped with three large slide-type gates, one for each hopper. You need only place a conveyor under the gate and open it for the unloading operation. And the flow can be controlled to meet the conveyor capacity.

FLAVOR FASHIONS

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Probably the real beginning of flavor fashions and the fashioning of flavors was around 4000 BC, when pepper, mustard, cumin, and curry were first discovered, ground by mortar and pestle, and added to food. Actually, the development of every culture or nation has always been the same. Man first had to devote his waking hours to securing food, and so eating was just gnawing and gulping. When culture advanced to where both food and time were available, then man relaxed, enjoyed civilized eating and food fashions evolved. Food was then prepared to whet the imagination and man tasted and sipped (as he does now) instead of gnawing and gulping.

Today's tasting and sipping are oriented around convenience foods. Today's fashionable homemaker wants meals in minutes but still wants to feed her family nutritious, well-balanced and flavorful meals--foods that are styled and structured for quick and easy preparation. You in the potato industries are to be congratulated for being the leaders in this field.

As you well know, taking your basic raw material and manufacturing it into the many dozens of convenient products places more emphasis on the flavor properties. A scientific approach to the sensory evaluation of flavors can aid in fashioning flavors which will aid in successful flavor fashions. Thus, I would like to point out the role that a sensory evaluation laboratory can play in this important area.

First, let us define flavor as used in sensory evaluation. The main parts of flavor are taste, odor, and touch or mouth feel. Although thousands of dollars are invested in intricate instruments which tell us more about the compositions of foods, no machine can perceive flavor in the manner used by that intricate machine called man. Thus, scientific flavor evaluation must use people.

Laboratory flavor tests may be divided into two main types, difference and preference tests. In difference testing, the food is analyzed for flavor differences as such, with no personal like or dislike involved. In preference testing, we are testing the judges' reaction to the food, the degree of like or dislike, or pleasantness or unpleasantness. Right now it is a good time to point out that preference and acceptance are different. Preference is the relative degree of like or dislike between two or more products, whereas acceptance means the person's degree of accepting or utilizing a product. Under acceptance there are many other factors, such as price and package, that must be considered. Thus, acceptance cannot be determined in any laboratory situation but is the objective of market studies. In laboratory flavor panel studies, the old journalistic questions of why? what? where? who? when? must first be answered.

<u>Why</u> means the specific objective(s) of the test. Is it to determine differences or preferences? When people unfamiliar with flavor evaluation studies are first asked this question, their usual answer is "I just want to know which sample is best." However, further discussion will often reveal that there has been a change in process, or source of an ingredient, or holding time so that the real objective is to determine whether the flavor of the new lot is different from that of the standard. Thus all that is required is a difference test. Only when a difference is detected is additional testing required. These tests may be difference tests of the analytical descriptive type, which are designed to locate the differences--in mouthfeel, flavor intensity, etc. Or they may be tests to determine the direction of the flavor difference--that is, whether the new process or material causes an increase or decrease in preference.

After the objectives have been clearly outlined, the test that will best meet these objectives can be chosen. There are several types of simple difference methods such as the triangular, duo-trio, paired comparison, and series paired comparisons that are based on reliable statistical designs. These tests are easy to conduct and analyze and will give you reliable answers. There are also several well established methods of preference testing such as paired comparison, rank, and hedonic scaling.

What samples to use must be carefully considered, because any test is only as reliable as the samples. As you well know, potatoes can and do vary even when grown in the same field at the same time under apparently the same conditions. Thus, care must be taken to get representative samples.

Where the tests are conducted is also important. The testing area should be conducive to concentration and free from distracting noise and odors. Individual booths are not essential, provided distracting influences can be controlled. Controlled lighting, sinks for expectorating sample, and distilled water for rinsing are desirable but not essential.

Who should serve on the flavor panel is important. For determining flavor differences, we choose people who we know have the ability to detect differences in the food products. Judges who have high acuity for flavor differences in potatoes may or may not be sensitive to flavor differences in other products. Thus, judges serving on difference panels are usually selected and then trained with the test product, so that we know they will give reliable, reproducible judgments. For preference panels, trained judges are not normally used. Actually, when we are conducting a preference test we are trying to get some indication of consumer reaction. The trained judge is more apt to be too sensitive to flavor differences and thus not a good representative of a consumer opinion. In preference tests, the main concern is drawing a conclusion from a too small, nonrepresentative population or panel of judges. For preference testing here in the O.S.U. Flavorium, we use university students chosen only on a first-come, first-served basis, and have 150 to 200 judges on the panels.

When should tests be conducted? For difference testing, the exact time of day does not seem to be as important as a time that is convenient. No test can be conducted unless the judges cooperate. Judges are busy with their own work. Thus, scheduling at the most convenient time seems to work best for difference tests. Here in the Flavorium, difference tests are normally conducted at about 9:30 a.m. and 2:30 p.m., just before the

morning and afternoon coffee breaks. For preference testing, the time of day can influence the judgment level. The test hours for the student preference panels are between 8:30 and 11:30 a.m. and 1:30 to 4:30 p.m. We have recorded judgments by hourly divisions during the day and find, for most products, a lower score at the beginning of the morning, rising to a peak around 11 o'clock and then dropping off again between 11 and 11:30. In the afternoon, the same relative pattern follows although the peak is more apt to be reached around 3 o'clock with a leveling off after this time. However, in preference testing, it is usually not the absolute score that is of interest but the relative difference in scoring between samples, and the time of day does not seem to influence this factor.

There are many "common sense" factors that must be considered in any type of flavor evaluation. For example, the coding of samples with letters or numbers that will not bias results and the number of samples in the test must be considered as well as their order of presentation. Highly trained judges tasting products with mild or bland flavors may be able to test as many as 8 or 10 samples at one time. Untrained preference judges will usually not be willing to taste more than three or four samples at a time. The order of the samples on the tray needs to be rotated so that every sample is judged an equal number of times in each position. The type of serving container, the amount of sample, the temperature of the samples--all such factors need to be controlled in order to secure valid test data.

As the market for structured, convenience foods grows, it will become increasingly important to learn more about flavor differences and flavor preferences. Laboratory flavor panels can and should be a valuable tool in your product development and quality control programs.

FOOD MANAGEMENT IN KITCHENS OF TOMORROW

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In the past ten years the management requirements of food service have changed, not only in institutional food service, but in other areas as well. Ten years ago a presentation on this topic could have been covered in a very short period. There have been little change in equipment, in products, or even in the management approach used in institutional food service. These

same generalizations could be applied to many or all segments of the food service industry. Indeed, the entire industry, with the exception of the agricultural segments, was basically "status quo" in its operation. Success or failure was based on efficency of execution as opposed to innovative processing, new products, or innovations in management theory and practice.

Some background is necessary to understand what has happened. In kitchens, the manager has only five basic components with which to work. These are his menu, the products he purchases, the equipment he uses, the labor who operates the equipment, and finally, his service technique. These components are basic to the institutional kitchen, the in-plant kitchen, a kitchen in a home, or a kitchen in a restaurant.

It is important to establish how these four kinds of kitchens were managed in the past. The institutional kitchen utilized large equipment which was driven by steam, gas or electricity. Design and use had changed very little over the years. It consisted of ranges, large kettles, large dishwashers, pot-and-pan sinks, work tables, walk-in-type refrigeration, and relatively small freezers. The arrangement of most institutional kitchens was standard. The staff people were usually local inhabitants with long seniority, unskilled or semiskilled. They tended to be housewives who augmented family income by work in food service operations. The products they prepared were brought to the kitchen in a raw state and each day they began by cleaning and preparing the basic raw product. The products fitted a standard "All-American" menu composed of meat, potato, vegetable, dessert, and beverage combinations. The "All-American" meal was roast beef, mashed potatoes, green peas, apple pie and milk.

The employees were not required to prepare ethnic or sauce dishes since these were considered to be inappropriate to an institutional food situation. Highly spiced items were also considered unsuitable. The food was served either through a cafeteria line, or more often to tables in bowls or on platters (family style) and passed around by consumers.

The home kitchen usually contained a range and oven, a refrigerator, a sink, and in some cases a small freezer. The products used were prepared from their natural state. The menu however, might vary with the ethnic background of the family. However, there was little interchange of menu items from one home to another. Few English families ate Italian foods. Mexican foods were little known outside the Southwest. Swedish, Central European or other "non-American" foods were served in homes with a heritage of preference for certain types of foods.

The restaurant kitchen followed the same pattern, but used smaller quantities than those utilized in institutional kitchens, usually with more variety. However, most restaurants were highly specialized. Italian, French, Swedish, Chinese, and American restaurants used ethnic oriented menu patterns with little attempt to produce foods to satisfy a broad range of publics. Service was highly accented. Some cafeteria restaurants appeared although they were not patronized by great numbers.

The industrial plant operation consisted then, and basically still does, of one meal sandwiched between morning and afternoon coffee break. The menu was heavily "All-American." Service was direct and accented speed rather than atmosphere. Products again were processed from a raw state and prepared daily for service. The personnel in the kitchen were semi- or low-skilled. The only skilled labor in the food service industry was found in restaurants where trained chefs prepared the ethnic foods that the restaurants served.

The situation described above has changed dramatically in recent years, as a result of an explosion in size of the food service market and changes in its environment. In 1950 the entire food service industry grossed approximately 62 billion dollars. In 1966 it approached 90 billion dollars, and in 1977 it may approximate 140 billion dollars. Recent studies indicate that in 1975 over 40 percent of all meals will be consumed outside the home. The opportunity is, therefore, 56 percent greater for commercial food operators in the market of 1977 than it is currently. The food service industry continues to maintain a 19.5 percent relationship to gross national product. The size of this market would stagger the food service manager of some years ago. Four things have happened with regard to the environment of food service operators and have had great impact on kitchen operation. They are:

1. The utilization of frozen foods and freezing equipment.
2. Basic changes in the eating patterns of Americans.
3. Discoveries in electronics resulting in innovation and technical change in equipment.
4. Significant changes in the availability of labor.

Today's supermarkets are well stocked with frozen products, ranging from fish to citrus to vegetables and fruits. Included are many entrees, which increase in number each year. It is rare today to find a supermarket that does not have more running feet of cabinet devoted to frozen prepared products than it does to fresh meat or fish counters. This kind of visual demonstration of the impact and utilization of frozen foods is equally valid (or perhaps even more valid) in the institutional restaurant and plant

food service areas. In addition, almost all refrigerators sold today contain freezing compartments and in many homes separate freezers are maintained and stocked with entrees and other products.

The American population today is exposed to various ethnic foods: pizza, spaghetti, goulash, stroganoff, enchiladas, tortillas, fish, lamb, pasta dishes, and others. The eating public is sophisticated and not satisfied with the bland and rather constant "All-American" diet of the past. By the time they reach high school children have been exposed to most foods from the entire spectrum of possible menus and by the time they reach adulthood are equal in their sophistication to yesterday's gourmets. This has been made possible by dramatic changes and improvements in our transportation and distribution systems and in the presence of equipment to store, handle, process and prepare the various food products.

The electronics industry has worked with amazing success in the area of microwave, quartz, radar, and other electronic cooking procedures. These dramatically shorten the time necessary to prepare foods and in addition make it possible by coupling the electronic equipment with freezing capability to produce pre-manufactured entrees of high quality and with the possibility of infinite selection. As a result, kitchen equipment is being redesigned, made lighter, more compact and more efficient. We also note the redesign of china and silverware, the use of plastics and paper for service, and significant impacts on kitchen design and function.

At the same time the work force available to commercial food service operators has dwindled. Jobs in other industries have drawn from the unskilled and low-paid members of the food service industry and reduced its labor force. The mobility of the American family has created training and turnover problems for food service operators. It is rare to find long service in a restaurant or institutional kitchen. The manager is therefore faced with untrained labor which is difficult to recruit and who have low skills in food preparation. The result of this is to drive the manager to the use of premanufactured quality-controlled food items.

This analysis points out trends for management to heed -

1. Due to electronic cooking equipment, preparation times will change with resulting changes in labor needs. The requirement will not be skilled labor, but rather labor that can follow scheduling techniques and operate more sophisticated equipment. Cooking will be done at high rates of speed, requiring close attention.
2. Research and development in the manufacture of food products ranging from entrees to desserts will rise

dramatically. In 1953 only $60 million was expended for research and development within the food industry. In 1964 the figure reached $130 million and by 1967 had reached $160 million.

3. There will be severe problems in the securing and training of labor.
4. The use of automatic dispensing equipment will grow.

The American economy has grown at the rate of 2 to 4 percent per year in recent years. All industry has grown at the rate of approximately 14 percent, but the vending industry has grown at the rate of 25 to 30 percent per year. We expect that this growth will continue and perhaps even accelerate.

The future can be anticipated from these trends, which are further validated by results of a study by Institutions Magazine. This journal conducted a survey which indicated that food products used in one kitchen or one area or one segment of the food service industry will be used by all. Currently, about 60 percent of all respondents use cake and pancake mix. About 30 percent use soup and sauce mixes. Almost 66 percent use frozen vegetables. About 50 percent use preprocessed potatoes. About 25 percent use precooked, preshaped meats. About 33 percent use precooked breaded fish. About 10 percent use precooked, preshaped poultry. In the kitchens of tomorrow, products will have been manufactured by central plants and the same product, packaged differently, will be supplied to all kitchens, whether they be home, institutional, industrial, or restaurant. Labor will change from hand to machine as a result of convenient, pre-prepared foods.

THE GRIM BATTLE FOR A PLACE IN THE MARKET BASKET

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Every student of economics soon learns that commodity prices obey the laws of supply and demand. When supplies are high or demand is low, prices fall. Potato growers learned this harsh lesson once again in 1967 when a bumper crop resulted in disastrously low prices. Unfortunately, while developments in agricultural science have made it relatively easy to expand the potato crop, we have much to learn about how to increase demand.

Growers look longingly on foreign markets as one way of increasing demand. Are foreign markets a likely outlet for U.S. potatoes and potato products? It does not appear so. Because of shipping costs and storage problems, agricultural commodities high in moisture are not well adapted to export. This is one of the reasons why low-moisture commodities such as wheat, cotton, corn, soybeans, tobacco, and rice accounted for about 2/3 of the value of our farm exports in the 1946-68 period.

Fresh potatoes at 80 percent moisture have special problems in storage and shipping. Only 2.25 million cwt., less than one percent of the more than 300 million cwt. produced in the U.S. in 1967, were exported.

How about dry potato products for export? When the export market for dehydrated instant potatoes, granules, and flakes increased from 7.5 million pounds in 1965 to 9.5 million pounds in 1966, there was hope that this might represent an increasing trend. However, in 1967 the export of potato flakes and granules dropped to a disappointing 9.1 million pounds. This was less than 3 percent of the estimated domestic production of 325 million pounds. At the same time there has been an expansion of potato processing in Europe with some U.S. firms opening European subsidiaries. It would appear that for many years to come the primary outlet for our potatoes, fresh or processed, will continue to be the U.S. market. Unfortunately, this is a rough tough area of competition.

The most important limiting factors in food consumption by middle-class Americans are not economic or nutritional but preferences. The average housewife buys what her family likes and is capable of consuming. The volume of a human stomach is, depending on age and sex, from 2 to 5 pints. A common declaration at a dinner table, after a big meal, is "I'm full!" The only way to get more potatoes into a stomach before it is "full" is to replace something else. This is the aim of marketing experts today--to "bump" some other product.

There is another market, of unknown size, of low-income families who offer a possibly expanded demand for low-cost potato products. A part of this market recently used dehydrated potatoes, perhaps for the first time. The U.S. Department of Agriculture has a program of aid to needy families. In 1968 more than one million cases of dehydrated potatoes, instant granules and flakes, fortified with vitamins A and C to help improve the nutritional level, were purchased by the U.S. Department of Agriculture for donation to needy families. This special market, however, is not the one involved today in the advertising battle in TV and

magazines, although we can hope that someday soon it will be because of greater purchasing power of its constituents. Most of my comments will be directed to what perhaps might be described as the great middle class market for which the advertisers are fighting.

The position of potatoes as the favorite vegetable of the American people makes it an obvious target for other foodstuffs looking for an increased share of the market basket. It is little wonder that the rice industry with an annual per capita consumption in the U.S. of 7.5 pounds looks with envy on potatoes, with a per capita consumption of 110 pounds. In a recent advertising campaign in national magazines, the rice industry sponsored full page ads aimed at capturing a portion of the potato market, with such headings as "I Hate Potatoes" and "Did You Ever See a Fat Chinese?" This aggressive "no-holds barred" battle has not been confined to potatoes and rice. A large food company marketing a new orange drink recently sponsored television ads showing a small boy saying "I Hate Orange Juice!"

It may be some small comfort to potato growers to realize that many foods beside potatoes are now fighting a grim battle for a place in the market basket. These foods have the added disadvantage that many of their competitors can use low-cost ingredients in "imitation" products.

The dairy industry particularly illustrates the effect of low-cost substitutes. One classic example of the changes wrought by aggressive marketing and research is oleomargarine. Although margarine first appeared on the American market about 1885, it wasn't until 1957 that per capita consumption reached 8.6 pounds, passing the 8.4 pounds of butter per capita. Only ten years later per capita consumption of oleo had reached 11 pounds while butter had shrunk to 5.5.

Other dairy substitutes such as "coffee whiteners" and "synthetic dessert toppings" have appeared in recent years. In only a short time they have replaced a large part of the market formerly held by whipping cream and coffee cream. It is estimated that coffee whiteners have displaced about 46 million pounds of butterfat annually. A new threat to the dairy industry is a product known as "filled milk," a mixture of skim milk and vegetable oils. Although this product has been known and marketed for fifty years, only in recent years has it been aggressively marketed. While filled milk has made little impact on the national market to date, it has replaced 20 percent of the milk market in Hawaii and 8 percent in Arizona.

Sugar is another industry worried about substitutes. The production of calcium cyclamate, an important synthetic sweetener, rose from 3 million pounds in 1962 to 15 million pounds in 1967. Although much of this increase represented a new market for new products, some of it has served to replace sugar in certain products. It has been estimated that by 1970 it will replace 3 percent of the sugar market. Approximately 20 percent of carbonated beverages are now made with synthetic sweeteners.

Some food processors are marketing substitutes not only for other food products, but for entire meals. For example, there are now several kinds of "Instant Breakfast" on the market. One can only wonder if Instant Lunch and Instant Dinner can be far behind.

There are many ways in which one food can substitute for another. For example, one large chain store in California makes its own frozen fruit pies and cream pies. Although cream pies made their appearance only about five or six years ago, they have taken a large part of the market formerly held by fruit pies. This is because a frozen fruit pie is not really as convenient a dessert as a frozen cream pie. To bake a frozen apple pie one must place it in the oven about an hour before dinner. On the other hand all that is necessary for serving a frozen cream pie is to remove it from the freezer. And like ice cream, the pie is ready to eat even while cold.

Soybean protein has been used in increasing amounts in recent years to make meat-like products. Such products may be formed either from fibers extruded from a soybean protein slurry or the soybean protein may be compressed in various ways to make a textured vegetable protein. Soy protein products are ingeniously colored and flavored to resemble a wide variety of meat or fish products. Manufacturers of these products are able to closely control protein, fat and carbohydrate for special dietary purposes, if desired.

It is true that processed potato products have "bumped" some portion of the fresh potato market. While those interested in fresh potatoes may regret this, there is little doubt that the explosive growth of "convenience products" made from potatoes has halted the declining consumption of potatoes. We are going to have to fight to hold our own against many determined competitors. Luckily potatoes possess certain virtues of flavor, cost, texture, acceptability, and versatility that no synthetic substitute has yet been able to duplicate. It will be the job of these utilization conferences for many years to come to supply potato growers and potato processors with new ammunition about new products, processes, production, marketing, etc. to help win the grim battle for a place in the market basket.

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